THE CAMBRIDGE SCHOOL

A PROJECT OF AZAM ACADEMY

CHEMISTRY

FOR CLASS – 9th

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CHAPTER # 1
Fundamental of chemistry

Self-assessment: 1.1:

1. Hair contain a special class of protein called keratin, which are present in nails and wool.

Ans: Biochemistry.

2. Acetylene is a simplest hydrocarbon that contain carbon-carbon triple bond. Hydrocarbons are the compounds of carbon and hydrogen.

Ans; Organic Chemistry.

3. White lead is a pigment used of artists for centuries, the metal Pb in the compound is extracted from its ore, galena (PbS).

Ans: Industrial Chemistry.

4. Sulphuric acid (H_2SO_4) is weaker than hydrochloric acid.

Ans: Analytical chemistry.

5. Gases can be compressed by applying pressure.

Ans: physical chemistry.

6. Some example of complete protein food are meat, milk and eggs.

Ans: biochemistry.

7. Element radium decays by emitting alpha particles and is converted into another element radon.

Ans: nuclear chemistry.

8. Calorimeter is a device that measure the amount of heat, a substance absorbs on heating or emits on cooling.

Ans: analytical chemistry.

Self-assessment: 1.2:

Write the empirical formula of compound containing carbon to hydrogen in the following ratios:

a) 1:4

Ans: simplest whole number ratio is 1:4

Empirical formula=CH_4.

(b) 2:6

Ans: actual whole number ratio=2:6

Simplest whole number ratio= 1:3

Empirical formula = CH_3

(c) 2:2

Ans: actual whole number ratio=2:2

Simplest whole number ratio= 1:1

Empirical formula=CH

(d) 6:6

Ans: actual whole number ratio= 6:6

Simplest whole number ratio= 1:1

Empirical formula= CH

Self- assessment:1.3:

Q.1. Aspirin is used as mild pain killer. There are nine carbon atoms, eight hydrogen atoms, and four oxygen atoms, in this compound. Write its empirical and molecular formulas.

Ans: empirical formula of aspirin is $C_9H_8O_4$.

Molecular formula of aspirin is $C_9H_8O_4$.

Because the compound has already in simplest whole number ratio of atoms. Therefore empirical and molecular formula of these compounds is same.

Q.2. Vinegar is 5 percent acetic acid. This contains 2 carbon atoms, four hydrogen atoms, and 2 oxygen atmos. Write it's empirical and molecular formulas.

Ans: molecular formula of vinegar is $C_2H_4O_2$. .

Actual whole number ratio = 2:4:2

Simplest whole number ratio= 1:2:1

Empirical formula of vinegar is CH_2O.

Q.3. caffeine ($C_8H_{10}N_4O_2$) is found in tea and coffee. Write the empirical formula of caffeine.

Ans: actual whole number ratio is 8:10:4:2

Simplest whole number ratio is 4:5:2:1

Empirical formula of caffeine is $C_4H_5N_2O$.

Self-assessment 1.4:

1. Potassium chlorate ($KClO_3$) is used commonly for the laboratory preparation of oxygen gas. Calculate its formula mass.

Ans: formula mass of $KClO_3$ = 39+35.5+3X16

$$=39+35.5+48$$

$$= 122.5amu.$$

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2. When baking soda, $NaHCO_3$ is heated released carbon dioxide, which is responsible for the rising cookies and bread. Determine the formula masses of baking soda and carbon dioxide.

Ans: formula mass of $NaHCO_3$= 23+1+12+3X16

= 23+1+12+48

=84amu.

Formula mass of CO_2= 12+2X16

=12+32

=44amu.

3. Following compounds are used as fertilizers. Determine the formula masses.

i) Urea $(NH_2)_2CO$.

Formula mass of urea $(NH_2)_2CO$= 2X14+2X2+12+16

= 28+4+12+16

= 60amu.

ii) Ammonium nitrate, NH_4NO3.

Formula mass of ammonium nitrate NH_4NO_3= 14+1X4+14+3X16

=14+4+14+48

= 80amu.

Self- assessment: 1.5:

Explain why?

1. An oxide ion has -2 charge.

Ans: oxygen has nucleus of 8 protons and 8 neutrons. Thus its nucleus has a total charge of +8. Around the nucleus in the in the ions are 10 electrons, with a total charge of -10. The charge on the ion is +8+(-10 = -2 oxide ion O^{-2}(to complete its octet).

2. Magnesium ion, Mg^{+2} has +2 charge.

Ans: magnesium has a nucleus of 12 protons and 12 neutrons. Thus its nucleus has a total charge of +12. Around the nucleus, in the ion are 10 electrons, with a total charge of -10. The charge on the ion is +12+ (-10) =+2 magnesium ion Mg^{+2}(to complete its octet).

3. Sulphide ion, S^{-2} has -2 charge.

Ans: sulphur has a nucleus of 16 protons and 16 neutrons. Thus its nucleus has total charge of +16. Around the nucleus, in the ion are 18 electrons, with a total charge of -18. The charge on the ion is +16+ (-18) = -2 sulphide ion S^{-2}(to complete its octet).

Self-assessment: 1.6:

Identify the ions, molecular ions, and free radicals from the following species.

CN^-, .CN, He^{+2}, N^{-3}, :O: ,: N.

Ans: ions: N^{-3} , He^{+2}

Molecular ions: CN^-

Free radicals: :O: ,   :N: ,   .CN

Self- assessment: 1.8:

Calculate the mass of one mole of

(a)copper

Ans: mass of one mole of copper = 63.5g/mole

(b) Iodine

Ans: mass of one mole of iodine = 2X 127

= 254g/mole

(c) Potassium

Ans: mass of one mole potassium = 39g/mole

(d) Oxygen

Ans: mass of one mole of oxygen = 2X16

=32g/mole

Self-assessment: 1.9:

Q.1. the molecular formula of a compound used for bleaching hair is H_2O_2. Calculate

(a) Mass of this compound that would contain 2.5moles.

Ans: given: no of moles= 2.5moles

Find: mass in grams=?

Solution: molar mass of H_2O_2 = 1X2+16X2

=2+32

= 34g/mole

Mass in grams= no of moles X molar mass

= 2.5moles X34g/mole

=85g

(b) No of moles of this compound that would exactly weigh 30g.

Ans: Given: mass in grams= 30g

Find: no of moles=?

Solution: no of moles= mass in grams/molar mass

$$= 30g/34gmole^{-1}$$

$$= 0.88moles.$$

Q.2. a spoon of table salt, NaCl contains 12.5g of this salt. Calculate the number of moles it contains.

Ans: Given: mass in grams= 12.5g

Find: no of moles=?

Solution:

Molar mass of NaCl   = 23+35.5

$$=58.5g/mole$$

No of moles   = mass in grams/molar mass

$$= 12.5g/58.5gmole^{-1}$$

$$=0.21moles.$$

Q.3. before the digestive systems X-rayed, people are required to swallow suspensions of barium sulphate ($BaSO_4$). Calculate the mass of one mole of $BaSO_4$.

Ans: Given= no of moles= 1mole

Find: mass of $BaSO_4$=?

Solution: molar mass of $BaSO_4$= 137+32+4X16

$$=137+32+64$$

$$= 233g/mole$$

Mass in grams= no of moles X molar mass

=1moleX 233g/mole

$$=233g$$

Self-assessment: 1.10:

Q.1. aspirin is a compound contains carbon, hydrogen, and oxygen. It is used as a pain killer. An aspirin tablet contains $1.25X10^{30}$molecules.how many moles of this compounds are present in the tablet?

Ans: Given: no of molecules= $1.25X10^{30}$molecules

Find: no of moles=?

Solution: no of moles=no of molecules/N_A

Avogadro's no = N_A = $6.022X10^{23}$

No of moles= $1.25X10^{30}/6.022X10^{23}$

= 0.207X10^{7}moles

= 2.07X10^{6}moles.

Q.2. A method used to prevent rusting in ships and underground pipelines involves connecting the iron to a block of a more active metal such as magnesium. This method is called cathodic protection. How many moles of magnesium are present in 1 billion (1X10^9) atoms of magnesium.

Ans: Given: no of atoms= 1X10^{9}atoms

Find: no of moles=?

Solution: no of moles= no of atoms/N$_A$

Avogadro's no = N$_A$= 6.022X10^{23}

No of moles= 1X10^9/6.022X10^{23}

= 0.166X10^{-14}moles

= 1.66X10^{-15}moles.

Review questions:

Q.6. calculate the number of moles of each substance in sample with the following masses:

a) 2.4g of He

Ans: given: mass in gram= 2.4g of He

Find: no of moles=?

Solution: molar mass of He= 4g/mole

No of moles= mass in gram/molar mass

$$=2.4g/4gmole^{-1}$$

$$= 0.6moles.$$

b) 250mg of carbon

Ans: given: mass in gram= 250mg of carbon=250/1000=o.25g

Find: no of moles=?

Solution: molar mass of carbon= 12g/mole

No of moles= mass in gram/molar mass

$$=0.25g/12gmole^{-1}$$

$$= 0.020 moles.$$

c) 15g of sodium chloride

Ans: given: mass in gram = 15g of NaCl

Find: no of moles=?

Solution: molar mass of NaCl= 23+35.5

$$=58.5g/mole$$

No of moles= mass in grams/molar mass

$$=15g/58.5gmole^{-1}$$

$$= 0.256moles.$$

d) 40g of sulphur

Ans: given: mass in gram= 40g of S

Find: no of moles=?

Solution: molar mass of S= 32g/mole

No of moles= mass in grams/molar mass

$$= 40g/32gmole^{-1}$$

$$=1.25moles.$$

e) 1.5kg of MgO

Ans: given: mass in grams=1.5kg of MgO=1.5X1000=1500g

Find: no of moles=?

Solution: molar mass of MgO= 24+16

$$=40g/mole$$

No of moles= mass of grams/molar mass

$$= 1500g/40gmole^{-1}$$

$$=37.5moles.$$

Q.7. calculate the mass in grams of each of the following samples:

a) 1.2moles of K

Ans: given: no of moles= 1.2 moles of K

Find: mass in grams=?

Solution: molar mass of K= 39g/mole

Mass in grams=no of moles X molar mass

$$= 1.2X39$$

$$=46.8g$$

b) 75moles of H_2

Ans: given: no of moles= 75moles of H_2

Find: mass in grams=?

Solution: molar mass of H_2= 2X1

$$=2g/mole$$

Mass in grams= no of moles X molar mass

=75X2

=150g.

c) 0.25moles of steam

Ans: given: no of moles= 0.25moles of steam

Find: mass in grams=?

Solution: molar mass of H_2O = 2X1+16

= 18g/mole

Mass in grams= no of moles X molar mass

= 0.25X18

= 4.5 g.

d) 1.05moles of $CuSO_4.5H_2O$

Ans: given: no of moles= 1.05 moles

Find: mass in grams=?

Solution: molar mass of $CuSO_4.5H_2O$= 63.5+32+16X4+5(2X1+16)

=63.5+32+64+5(18)

=63.5+32+64+90

= 249.5g/mole

Mass in grams= no of moles X molar mass

= 1.05X249.5

=261.45g.

e) 0.15moles of H_2SO_4

Ans: given: no of moles= 0.15moles of H_2SO_4

Find: mass in grams=?

Solution: molar mass of H_2SO_4= 2X1+32+4X16

= 2+32+64

=98g/mole

Mass in grams= no of moles X molar mass

=0.15X98

=14.7g.

Q.8. calculate the number of molecules present in each of the following sample:

a) 2.5moles of carbon dioxide

Ans: given: no of moles= 2.5moles of carbon dioxide

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Find: no of molecules=?

Solution: no of molecules=no of moles X N_A

Avogadro's no= N_A = 6.022×10^{23}

No of molecules= $2.5 \times 6.022 \times 10^{23}$

$$= 1.50 \times 10^{24} \text{molecules.}$$

b) 3.4moles of ammonia

Ans: given: no of moles= 3.4moles of ammonia

Find: no of molecules=?

Solution: no of molecules= no of moles X N_A

N_A = 6.022×10^{23}

No of molecules= $3.4 \times 6.022 \times 10^{23}$

$$= 2.05 \times 10^{24} \text{molecules.}$$

c) 1.09moles of benzene

Ans: given: no of moles= 1.09moles of benzene

Find: no of molecules=?

Solution: no of molecules= no of moles X N_A

N_A = 6.022×10^{23}

No of molecules= $1.09 \times 6.022 \times 10^{23}$

$$= 6.56 \times 10^{23} \text{molecules.}$$

d) 0.01moles of acetic acid

Ans: given: no of moles= 0.01moles of acetic acid

Find: no of molecules=?

Solution: no of molecules= no of moles X N_A

N_A = 6.022×10^{23}

No of molecules= $0.01 \times 6.022 \times 10^{23}$

$$= 6.022 \times 10^{21} \text{ molecules.}$$

Q.9. Decide whether or not each of the following is an example of empirical formula:

a) Al_2Cl_6

Ans: No, since 2:6 is not the simplest whole number ratio therefore Al_2Cl_6 is not empirical formula. Hence Al_2Cl_6 is a molecular formula.

b) Hg_2Cl_2

Ans: No, since 2:2 is not the simplest whole number ratio therefore Hg_2Cl_2 is not empirical formula. Hence Hg_2Cl_2 is a molecular formula.

c) NaCl

Ans: yes, since 1:1 is a simplest whole number ratio therefore NaCl is empirical formula.

d) C_2H_6O

Ans: yes, since 2:6:1 is a simplest whole number ratio therefore C_2H_6O is empirical formula.

Q.10. TNT or trinitrotoluene is an explosive compound used in bombs. It contains 7C-atoms, 6H-atoms, 3 N-atoms and 6 O-atoms. Write its empirical formula.

Ans: 7:6:3:6= simplest whole number ratio

Empirical formula= $C_7H_6N_3O_6$

Q.11. a molecule contains four phosphorus atom and ten oxygen atoms. Write the empirical formula of this compound. Also determine the molar mass of these molecules.

Ans: 4:10= actual whole number ratio

2:5 = simplest whole number ratio

Empirical formula = P_2O_5

Molar mass of P_4O_{10} = 4X31+10X16

=124+160

=284g/mole

Q.12. indigo ($C_{16}H_{10}N_2O_2$), the dye used to colour blue jeans is derived from a compound known as indoxyl (C_8H_7ON). Calculate the molar masses of these compounds. Also write their empirical formulas.

Ans. Molar mass of indigo ($C_{16}H_{10}N_2O_2$) = 16X12+10X1+2X14+2X16

= 192+10+28+32

=262 g/mole.

Empirical formula of indigo ($C_{16}H_{10}N_2O_2$):

Actual whole number ratio= 16:10:2:2

Simplest whole number ratio= 8:5:1:1

Empirical formula= C_8H_5NO

Molar mass of indoxyl (C_8H_7ON) =8X12+7X1+16+14

=96+7+16+14

=133g/mole

Empirical formula of indoxyl (C_8H_7ON):

Actual whole number ratio= 8:7:1:1

Simplest whole number ratio= 8:7:1:1

Empirical formula= C_8H_7ON

Q.13. identify the substance that has the formula mass of 133.5amu.

a) $MgCl_2$

b) S_2Cl_2

c) BCl_3

d)$AlCl_3$

Ans: a) formula mass of $MgCl_2$= 24+2X35.5

$$=24+71$$

$$= 95amu.$$

b) Formula mass of S_2Cl_2= 2X32+2X35.5

$$= 64+71$$

$$= 135amu.$$

c) Formula mass of BCl_3= 11+3X35.5

$$=11+106.5$$

$$= 117.5amu.$$

d) Formula mass of $AlCl_3$= 27+3X35.5

= 27+106.5

$$=133.5amu.$$

Hence formula mass of $AlCl_3$ is 133.5amu therefore option d is correct.

Q.14. calculate the number of atoms in each of the following sample:

a) 3.4moles of nitrogen atoms

Ans. Given: no of moles= 3.4moles of nitrogen

Find: no of atoms=?

Solution: no of atoms= no of moles X N_A

Avogadro's no N_a= $6.022X10^{23}$

No of atoms= $3.4X6.022X10^{23}$

$$= 2.04X10^{24} atoms.$$

b) 23g of Na

Ans. Given: mass in grams= 23g of Na

Find: no of atoms=?

Solution: molar mass of Na= 23g/mole

No of atoms= mass in g/molar mass X N_A

No of atoms= $23/23 \times 6.022 \times 10^{23}$

$= 6.022 \times 10^{23}$ atoms.

c) 5g of H atoms

Ans: Given= mass in grams= 5g of H

Find: no of atoms=?

Solution: molar mass of H= 1g/mole

No of atoms= mass in g/molar mass X N_A

$= 5/1 \times 6.022 \times 10^{23}$

$= 3.01 \times 10^{24}$ atoms.

Q.15. calculate the mass of the following:

a) 3.24×10^{18} atoms of iron

Ans: Given: no of atoms= 3.24×10^{18} atoms

Fins: mass in grams=?

Solution: molar mass of iron=56g/mole

Mass in gram= no of atoms X molar mass/N_A

$= 3.24 \times 10^{18} \times 56 \times 6.022 \times 10^{23}$

$= 3.01 \times 10^{-4}$ g.

b) 2×10^{19} molecules of nitrogen gas

Ans: Given= no of molecules= 2×10^{19} molecules

Find: mass in grams=?

Solution: molar mass of N_2= 2×14= 28g/mole

Mass in grams= no of molecules X molar mass/N_A

$= 2 \times 10^{19} \times 28/6.022 \times 10^{23}$

$= 9.3 \times 10^{-4}$ g.

c) 1×10^{25} molecules of water

Ans: Given: no of molecules= 1×10^{25} molecules

Find: mass in grams=?

Solution: molar mass of H_2O= $2 \times 1+16$= 18g/mole

Mass in grams= no of molecules X molar mass/ N_A

$= 1 \times 10^{25} \times 18/6.022 \times 10^{23}$

$= 2.99 \times 10^{2}$ g.

d) 3×10^{6} atoms of Al

Ans: given: no of atoms= 3×10^{6} atoms

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Find: mass in grams=?

Solution: molar mass of Al= 27g/mole

Mass in grams= no of atoms X molar mass/N_A

$$= 3X10^6 X 27/6.022X10^{23}$$

$$= 13.46X10^{-17}g$$

$$= 1.346X10^{-16}g.$$

Q.16. identify the branch of chemistry that deals with the following examples:

1. A cornstalk grows from seed.

Ann: Biochemistry.

Q.2. Dynamite ($C_3H_5N_3O_9$) explodes to form mixture of gasses.

Ans: Inorganic chemistry.

Q.3. purple iodine vapour appears when solid iodine is warmed.

Ans: physical chemistry.

Q.4. Gasoline (a mixture of hydrocarbons) fumes are ignited in an auto mobile engine.

Ans: organic chemistry.

Q.5. a silver articles tarnishes in air.

Ans: environmental chemistry.

Q.6. ice floats on water.

Ans: physical chemistry.

Q.7. sulphur dioxide is the major source of acid rain.

Ans: environmental chemistry.

Q.8. many other light chlorinated hydrocarbons in drinking water are carcinogens.

Ans: environmental chemistry.

Q.9. in Pakistan most of the factories use wet process for the production of cement.

Ans: industrial chemistry.

Q.10. carbon-14 is continuously produced in the atmosphere when high energy neutron from space collide with nitrogen-14.

Ans: nuclear chemistry.

THINK-TANK

Q.1. what mass of sodium metal contains same no of atoms as 12g of carbon?

Ans: Given: no of atom of C= 12g

No of atom of Na= no of atom of C

Find: mass of Na=?

Solution: molar mass of C= 12g/mole

No of atoms=mass in grams/molar mass XN_A

No of atoms of C= $12/12X6.022X10^{23}$

$= 6.022X10^{23}$atoms

No of atom of Na= $6.022X10^{23}$atoms

Molar mass of Na= 23g/mole

No of moles= no of atoms/N_A

$=6.022X10^{23}/6.022X10^{23}$

= 1mole

Mass in grams= no of moles X molar mass

= 1X23

Mass of Na   =23g

Q.2. what mass of oxygen contains same no of molecules as 42g of nitrogen?

Ans: Given: no of O_2 molecules= no of N_2 molecules

Mass of nitrogen= 42g

Find: mass of oxygen=?

Solution: molar mass of N_2= 2X14= 28g/mole

No of molecules= mass in grams/molar mass X N_A

No of molecules= $42/28X6.022X10^{23}$

$= 9X10^{23}$molecules of nitrogen

No of molecules of oxygen= $9X10^{23}$molecules

No of moles= no of molecules/N_A

$= 9X10^{23}/6.022X10^{23}$

= 1.5moles

Mass in grams= no of moles X molar mass

Molar mass of O_2 = 2X16 = 32g/mole

Mass of oxygen = 1.5X32

= 48g of oxygen.

Q.3. calculate the mass of one hydrogen in grams.

Ans: Given: no of H atoms= 1atom

Find: mass of H atom=?

Solution: molar mass of H= 1.008g/mole

Mass in grams= no of atoms X molar mass/N_A

$$=1 X 1.008/6.022 X 10^{23}$$

$$=1.67 X 10^{-24}g$$

Q.4. observe the given figure. It shows particles in a sample of air.

a) Count the substance shown in the sample

Ans: N_2, H_2O, O_2, CO_2, Ar. Total substance are 5.

b) Is air a mixture or pure substance? Explain?

Ans: Air is a mixture, with the following major constituent substances. Nitrogen, oxygen, water vapour, and carbon dioxide. Therefore air is homogenous mixture of several gases. Its not a pure substance.

c) Identify the formula of each substance in air.

Ans: N_2, O_2, H_2O, CO_2, Ar.

d) Decide whether each substance in air is an element or a compound.

Ans: nitrogen and oxygen are element whereas water and carbon dioxide are compounds.

e) What is the most common substance in air?

Ans: nitrogen is the most common substance in the air. (78% by volume)

Q.5. calculate the number of H-atom present in 18g of H_2O.

Ans: Given: mass of water= 18g

Find: no of H-atoms=?

No of water molecules=?

Solution: no of molecules= mass in grams/molar mass X N_A

Molar mass of H_2O= 2 X 1+16= 18g/mole

No of molecules= 18/18 X 6.022 X 10^{23}

$$=6.022 X 10^{23} \text{molecules 0f water}$$

We know that one H_2O molecules contains 2H atoms so no of H atoms= 2 X 6.022 X 10^{23}

$$= 1.204 X 10^{24} \text{atoms}$$

Q.6. calculate total number of atoms present in 18g H_2O?

Ans: Given: mass of water= 18g

Find: total no of atoms in H_2O=?

No of H_2O molecules=?

Solution: molar mass of H_2O= 2X1+16= 18g/mole

No of molecules=mass in grams/molar mass X N_A

= 18/18X6.022X10^{23}

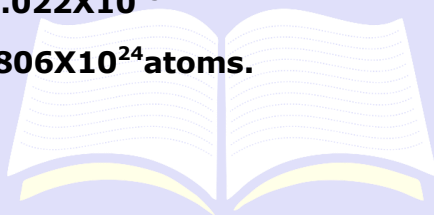**=6.022X10^{23}molecules of water**

We know that one H_2O molecule contains 2H and one oxygen, so total number is 3.

Total no of atoms= 3X6.022X10^{23}

=1.806X10^{24}atoms.

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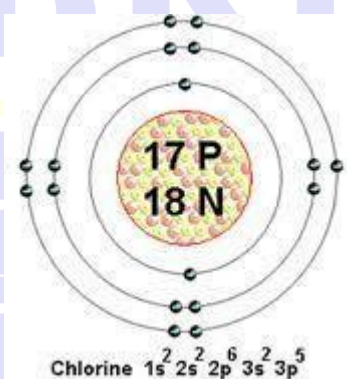# CHAPTER # 2
STRUCTURE OF ATOMS

Self Assessment

Self-Assessment Exercise 2.1:

Draw Bohr's model for the following atoms indicating the location of electrons, protons and neutrons.

a. Carbon (Atomic No.6, Mass No. 12)
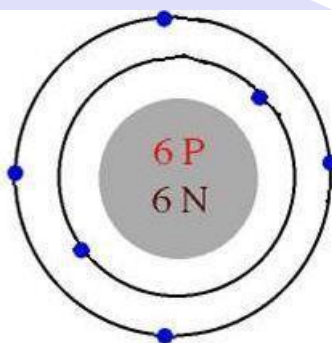
b. Chlorine (Atomic No. 17, Mass No. 35)

Self-Assessment Exercise 2.2:

Write complete electronic configuration of the following elements.

Al (Atomic No. 13) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

Si (Atomic No. 14) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

P (Atomic No. 15) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

S (Atomic No. 16) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

Cl (Atomic No. 17) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

Ar (Atomic No. 18) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Self-Assessment Exercise 2.4:

Write the electronic configuration for the following isotopes.

a. $_6C$

Electronic configuration: $1s^2\ 2s^2\ 2p^2$

b. $_{17}Cl$

Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

c. $_{17}Cl$

Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

REVIEW QUESTIONS

Q # 2: Give short answers.

1. Distinguish between shell and sub-shell.

Ans: SHELL:

- **Shell is a circular path around the nucleus in which electron revolves in an atom.**
- **Each shell is also called energy level.**
- **Each shell is described by a value "n" where n= 1,2,3........**

SUB-SHELL:

- **A sub-shell is a sub-energy level present in any shell.**
- **"n" value of a shell is placed before the symbol of a subshell.**
- **Subshells are s, p, d, f**

2. An atom is electrically neutral. Why?

Ans: An atom is electrically neutral because in any atom number of electrons are always equal to number of protons. As the relative charge on electron is -1 and on a proton +1. So when number of both protons and electrons is equal , atom becomes neutral.

3. Describe the presence of sub-shells in a shell.

Ans: A shell is further divided into subshells or sub energy levels. In K shell, there is only one sub-shell which is represented by 1s.In L shell, there are two sub-shells which are designated as 2s and 2p. M shell contains 3s, 3p and 3d while N shell contains 4s, 4p, 4d and 4f subshells.

4. Give notations for sub-shells of M shell.

Ans: M shell is further divided into three sub-shells which are represented as 3s, 3p, and 3d.

5. List the subshells of M shell in order of increasing energy.

Ans: Increasing order of energies of subshells of M shell is as follows;

3s < 3p < 3d

It means 3s is lower in energy than 3p which is further lower in energy than 3d.

6. Can you identify an atom without knowing number of neutrons in it?

Ans: yes, we can identify an atom without knowing number of neutrons in it if we know number of protons present in atom or its atomic number. This is

because, atomic number is the identity of an atom and atomic number represents number of protons present in the nucleus of any atom.

Q # 3:

The electronic configuration is listed incorrect. Explain what mistake has been made in each and write correct electronic configuration.

Ans:

(i) X = $1s^2, 2s^2, 2p^4, 3p^2$ (incorrect)

According to the Aufbau principle, electrons fill the lowest energy sub-shell that is available. In above electronic configuration, 2p can accommodate 6 electrons so the 2 electrons which are filled in 3p subshell , must be filled in 2p.

Correct electronic configuration: x = $1s^2, 2s^2, 2p^6$

(ii) y = $1s^2, 2s^1, 2p^1$ (incorrect)

According to the Aufbau principle, electrons fill the lowest energy sub-shell that is available. In above electronic configuration, two electrons must be filled in 2s before filling of 2p.

Correct electronic configuration: Y = $1s^2, 2s^2$

(iii) z = $1s^2, 2s^2, 2p^5, 3s^1$ (incorrect)

According to the Aufbau principle, electrons fill the lowest energy sub-shell that is available. In above electronic configuration, 2p can accommodate 6 electrons so the electron which is filled in 3s sub-shell , must be filled in 2p.

Correct electronic configuration: z = $1s^2 \, 2s^2 \, 2p^6$

Q # 4 : which subshell in each of the following pairs is lower in energy?

(a) 2s , 2p

Ans: 2s is lower in energy than 2p sub-shell.
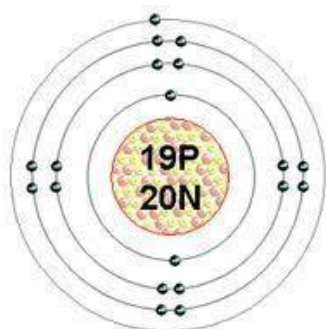
(b) 3p, 2p

Ans: 2p is lower in energy than 3p sub-shell.

(c) 3s , 4s

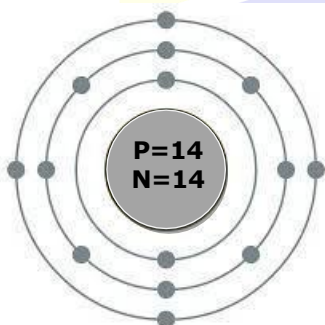**Ans: 3s is lower in energy than 4s sub-shell.**

Q # 5 : Draw Bohr's Model of an atom for the following atoms indicating the location of electrons, protons and neutrons:
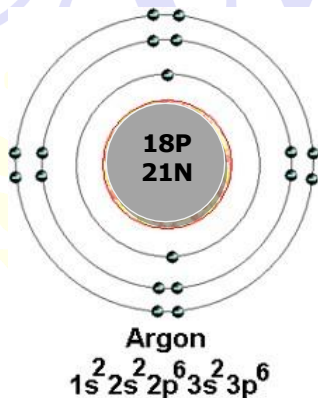
(a) Potassium (Atomic No. 19, Mass No.39)

Potassium
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
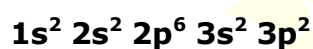
(b) Silicon (Atomic No. 14, Mass No. 28)

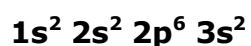
(c) Argon (Atomic No. 18, Mass No. 39)

Argon
$1s^2 2s^2 2p^6 3s^2 3p^6$

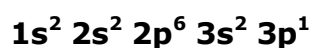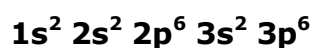**Q # 6: write electronic configuration for the following elements.**

a. Si

$1s^2 2s^2 2p^6 3s^2 3p^2$

b. Mg

$1s^2 2s^2 2p^6 3s^2$

c. Al

$1s^2 2s^2 2p^6 3s^2 3p^1$

d. Ar

$1s^2 2s^2 2p^6 3s^2 3p^6$

Q # 8: From textbook

Q # 9: From textbook

Q # 10: From textbook

Q # 11: The atomic number of an element is 23, and its mass number is 56.

a. How many protons and electrons does an atom of this element have?

Ans: As atomic number of an element represents number of protons or number of electrons present in it, so

No. of protons = 23

No. of electrons = 23

b. How many neutrons does this atom have?

Ans: Mass no = No. of protons + No. of neutrons

No. of neutrons = Mass No. – No. of protons

So,

No. of neutrons = 56 – 23

= 33

Q # 12 : The atomic symbol of aluminum is written as 13Al. what information do you get from it?

Ans: Atomic No. of Aluminum is 13 which means 13 protons and 13 electrons present in an atom of Aluminum. Mass No. of Aluminum is 27, from which we can calculate no. of neutrons also.

No. of neutrons = Mass No. – No. of protons

So,

No. of neutrons in 13Al = 27 – 13

= 14

Q # 14 : From textbook

Q # 15 : From textbook

Think tank

Q # 15: M-24 is a radioactive isotope used to diagnose restricted blood circulation, for example in legs. How many electrons, protons, and neutrons are there in this isotope. Valence shell electronic configuration of M is 3s1.

Ans : M-24 means Mass no. of this isotope is 24. From valence shell electronic configuration we can find no. of electrons present in this atom.

As valence shell electronic configuration of M-24 is 3s1 , so its complete electronic configuration will be $1s^2\ 2s^2\ 2p^6\ 3s^1$.

No. of electron = 11

As No. of electrons are equal to no. of protons in a neutral atom, so

No. of protons = 11

We know,

No. of neutrons = Mass No. – No. of protons

So,

No. of neutrons in M-24 = 24 – 11

= 13

Q # 16 : Two isotopes of chlorine are $_{35}Cl$ and $_{37}Cl$. How do these isotopes differ? How are they alike?

Ans : $_{35}Cl$ and $_{37}Cl$ are the atoms of same element having same no. of protons but different no. of neutrons.

Difference:

$_{35}Cl$ and $_{37}Cl$ have different number of neutrons present in them. $_{35}Cl$ have 18 neutrons in it while $_{37}Cl$ has 20 neutrons in it.

Similarity:

No. of protons and electrons are equal in Both $_{35}Cl$ and $_{37}Cl$. Both have 17 electrons and 17 protons.

Q # 17: How many electrons can be placed in all of the sub-shells of n=2 shell?

Ans: There are two sub-shells present in n=2 shell which are named as 2s and 2p. 2s can accommodate 2 electrons while 2p can accommodate 6 electrons. So total 8 electrons can be placed in all of the sub-shell of n=2 shell.

Q # 18: Mass no. of an atom indicates total no of protons and neutrons in the nucleus. Can you identify an atom without any neutron?

Ans: Protium (1H) is an isotope of Hydrogen whose mass no. is 1. It does not have any neutron. It has only one proton and one electron.

Protium
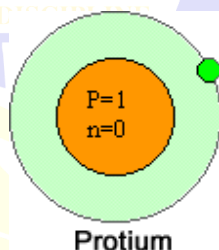
Q # 19: The table shows the nuclei of five different atoms.

Name of atom	Number of protons	Number of neutrons
A	5	6
B	6	6
C	6	7
D	7	7
E	8	8

a. Which atom has highest mass number?

Ans: E has the highest mass no.

b. Which two atoms are isotopes?

Ans: B and C are isotopes.

c. Which atom has least number of electrons?

Ans: A has least number of electrons.

d. Which atom will have electronic configuration $1s^2\ 2s^2\ 2p^3$.

Ans: D has electronic configuration $1s^2\ 2s^2\ 2p^3$

e. Which of the atom contains the most no. of electrons?

Ans: E has most number of electrons.

Q # 20: Naturally occurring nitrogen has two isotopes N-14 and N-15. Which isotope has greater number if electrons?

Ans: No. of electrons in any atom depend upon it atomic number. Atomic No. of nitrogen is 7, so both N-14 and N-15 have equal no. of electrons. Both have 7 electrons each.

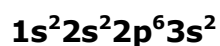**Department of Chemistry – the Cambridge School & College**

CHAPTER # 3
Periodic table and periodicity of properties

Self assessment exercise 3.1:

In which period and group the following elements are present in the periodic table?

(a) $_{12}$Mg

Electronic configuration:

$1s^2 2s^2 2p^6 3s^2$

n= 3

So Period: 3

No of valence electrons = 2

So Group: IIA

(b) $_{10}$Ne

Electronic configuration:

$1s^2 2s^2 2p^6$

n= 2

Period: 2

No of valence electrons = 8

Group: VIIIA

(c) $_{14}$Si

Electronic configuration:

$1s^2 2s^2 2p^6 3s^2 3p^2$

n= 3
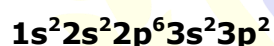
Period: 3

No of valence electrons = 4 Group: IVA

(d) $_5$B

Electronic configuration:
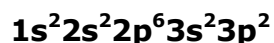
$1s^2 2s^2 2p^1$

n= 2
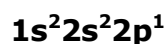
Period: 2

No of valence electrons = 3 Group: IIIA

Self assessment exercise 3.2:

Identify the group and period of the following elements on the basis of electronic configuration.
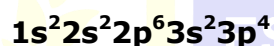
(a) $_{14}$Si

Electronic configuration:

$1s^2 2s^2 2p^6 3s^2 3p^2$

n= 3

Period: 3

No of valence electrons = 4 Group: IVA

(b) $_{16}$S

Electronic configuration:

$1s^2 2s^2 2p^6 3s^2 3p^4$

n= 3

Period: 3

No of valence electrons = 6 Group: VIA

(c) $_{9}$F

Electronic configuration:

$1s^2 2s^2 2p^5$

n= 2

Period: 2

No of valence electrons = 7 Group: VIIA

(d) $_{18}$Ar

Electronic configuration:

$1s^2 2s^2 2p^6 3s^2 3p^6$
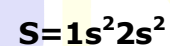
n= 3
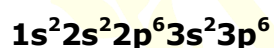
Period: 3

No of valence electrons = 8 Group: VIIIA

Self assessment exercise 3.3:

IA								VIIIA
	IIA		IIIA	IVA	VA	VIA	VIIA	R
T	S		Z	P				W
Q				X				Y

Electronic configurations of atoms of some elements are given below. Place them into groups and periods.

$P = 1s^2 2s^2 2p^2$ $\quad\quad Q = 1s^2 2s^2 2p^1$ $\quad\quad R = 1s^2$ $\quad\quad S = 1s^2 2s^2$

$T = 1s^2 2s^1$ $\quad\quad W = 1s^2 2s^2 2p^6$

$X = 1s^2 2s^2 2p^6 3s^2 3p^2$ $\quad\quad Y = 1s^2 2s^2 2p^6 3s^2 3p^6$ $\quad\quad Z = 1s^2 2s^2 2p^1$
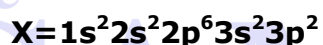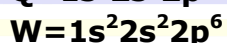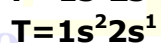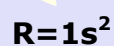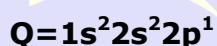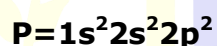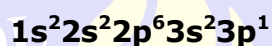
Self Assessment exercise 3.4:

1: Obtain the valence shell configuration of Al and S from their position in the periodic table.

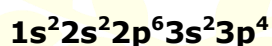**Atomic number of aluminium =13**

Electronic configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^1$$

n= 3

Period: 3

No of valence electrons = 3 Group: IIIA

This shows that aluminium is present in period number 3 and group number IIIA

Atomic number of sulphur =16

Electronic configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^4$$
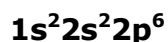
n= 3

Period: 3

No of valence electrons = 6 Group: VIA

This shows that sulphur is present in period number 3 and group number VIA

2: Find out the position of Ne (At. No 10) and Cl (At. No 17) in the periodic table.

Atomic number of Ne=10

Electronic configuration:

$$1s^2 2s^2 2p^6$$

n= 2

Period: 2

No of valence electrons = 8 Group: VIIIA

This shows that Neon is present in the period 2 and group VIIIA

Atomic number of Cl =17

Electronic configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^5$$

n= 3

Period: 3

No of valence electrons = 7 Group: VIIA

This shows that chlorine is present in the period 3 and group VIIA

Self assessment exercise 3.5:

Choose the element whose atoms you expect to have smaller shielding effect.

(a) F or Cl

F has smaller shielding effect because it has less number of inner shells as compare to Cl.

(b) Li or Na

Li has smaller shielding effect because it has less number of inner shells as compare to Na

(c) B or Al

B has smaller shielding effect because it has less number of inner shell as compare to Al

Self assessment exercise 3.6:

Choose the elements whose atom you expect to have smaller atomic radius in each of the following pairs.

(a) O or S

O has smaller atomic radius. This is because it has the lesser shell of electrons as compare to S.

(b) O or F

F has smaller atomic radius. This is because as you move from one element to the next on its right in the period. Another electron is added to the same

valence shell. The attractive force of the nucleus for the valence shell electron increases therefore the shell size and atomic radius decreases.

Self assessment exercise 3.7:

Which atom has the smaller ionization energy?

(a) B or N

B has smaller ionization energy. This is because a weaker force of attraction between the nucleus and the valence electron.

(b) Be or Mg

Mg has smaller ionization energy. This is because a greater shielding effect results in a weaker attraction of the nucleus for the valence electron.

(c) C or Si

Si has smaller ionization energy. This is because a greater shielding effect results in a weaker attraction of the nucleus for the valence electrons.

EXERCISE

Q.2: Give short answers.

(i) Write the valence shell electronic configuration of an element present in the 3rd period and group IIIA.

Ans: The element present in group IIIA and in the period 3rd is Al. The valence shell configuration is: $3s^23p^1$.

(ii) Write two ways in which isotopes of an element differ.

Ans:(1): Isotopes have different number of neutrons.

(2): They have different physical properties that is melting points.

(iii) Which atom has higher shielding effect Li or Na?

Ans: Na has the higher shielding effect. Thus is because as you move top to bottom in a group the shielding effect increases. This is due to increase in the shell.

(iv) Explain why Na has the higher ionization energy then K?

Ans: Na has higher ionization energy than K because as you move top to bottom in a group the ionization energy is decreases.

(v) Alkali metals belong to s-block in the periodic table why?

Ans: Alkali metals belong to s-block in the periodic table because their group number is I and period number is also 1 and the valence shell lie in the s.

Q.3: Arrange the elements in each of the following groups in order of increasing ionization energy.

(a) Li, Na, K

K<Na<Li

(b) Cl, Br, I

I<Br<Cl

Q.4: Arrange the element in each of the following in order of decreasing shielding effect.

(a)Li, Na, K

K>Na>Li

(b)Cl, Br, I

I>Br>Cl

(c)Cl, Br

Br>Cl

Q.5: Specify which of the following elements you would expect to have the greatest electron affinity? S, P, Cl.

Ans: Cl has greater electron affinity. As you move left to right across a period the electron affinity generally increases. This is due to increase in nuclear charge and decrease in the atomic radius.

Q.6: Electronic configuration of some elements are given below, group the elements in pairs that would represent similar properties.

$A=1s^2 2s^2$ $B=1s^2 2s^2 2p^6$ $C=1s^2 2s^2 2p^3$ $D=1s^2$
$E=1s^2 2s^2 2p^6 3s^2 3p^3$ $F=1s^2 2s^1$

$G=1s^2 2s^2 2p^6 3s^1$ $H=1s^2 2s^2 2p^6 3s^2$

- A and H have come in the same group due to their similar chemical properties.

- F and G have come in the same group due to their similar chemical properties.

- C and E have come in the same group due to their similar chemical properties.

- D and B have come in the same group due to their similar chemical properties.
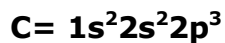
Electronic configuration:
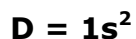
$A=1s^2 2s^2$

Period= 2
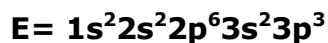
Group= IIA

$B= 1s^2 2s^2 2p^6$

Period= 2

Group= VIIIA

C= $1s^2 2s^2 2p^3$

Period= 2

Group= VA

D = $1s^2$

Period= 1

Group= IIA

E= $1s^2 2s^2 2p^6 3s^2 3p^3$

Period= 3

Group= VA

F= $1s^2 2s^1$

Period= 2

Group= IA

G= $1s^2 2s^2 2p^6 3s^1$

Period= 3

Group= IA

H= $1s^2 2s^2 2p^6 3s^2$
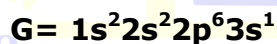
Period= 3

Group= IIA

Q.7: Arrange the elements in group and periods in Q.No.6.

IA				IIIA	IVA	VA	VIA	VIIA	VIIIA
	IIA			IIIA	IVA	VA	VIA	VIIA	D
F	A					C			B
G	H					E			

Q.8: For normal elements, the number of valence electrons of an element is equal to the group number. Find the group number of the following elements.
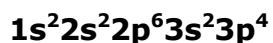
$_{13}$Al

Electronic configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^1$$
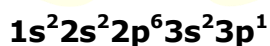
Group= IIIA

$_{32}$S

Electronic configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^4$$

Group= VIA

$_{19}$**K**

Electronic configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$$
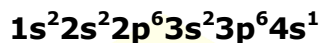
Group= IA

$_8$**O**

Electronic configuration:

$$1s^2 2s^2 2p^4$$
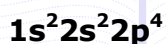
Group= VIA

Q.9: Write the valence shell electronic configuration for the following groups:

(a) Alkali metals:

Valence shell configuration=ns^1

(b) Alkaline earth metals;

Valence shell configuration=ns^2

(c) Halogens:

Valence shell configuration= $ns^2 np^5$

(d) Noble gases:

Valence shell configuration= $ns^2 np^6$

Q.10: Write electron dot symbols for an atom of the following elements.

(a) Be

Be:

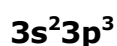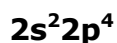**(b) K**

K.

(c) N

:N:

(d) I

:I:

Q.11: Write the valence shell electronic configuration of the following elements.

(a) An element present in period 3 of group VA.

   $3s^2 3p^3$

(b) An element present in period 2 of group VIA.

$2s^22p^4$

Q.12: Copy and complete the following table:

| Atomic number	Mass number	No of proton	No of neutron	No of electron
11	23	11	12	11
14	29	14	15	14
22	47	22	25	22
13	27	13	14	13

Q.13: Imagine you are standing on the top of Neon-20 nucleus. How many kinds of sub atomic particles you would see looking down into the nucleus and those you would see looking out from the nucleus?

Ans: The sub atomic particles you would see looking down into the nucleus are protons and neutrons while those you would see looking out from the nucleus are electrons.

Q.14: Chlorine is a reactive element used to disinfect swimming pools. It is made up of two isotopes Cl-35 and Cl-37. Because Cl-35 is more than Cl-37, the atomic mass of chlorine is 35.5 amu. is closer to 35 then 37. Write electronic configuration of each isotope of chlorine. Also write symbols for these isotopes (atomic number for chlorine is 17).

Ans: ^{35}Cl

Electronic configuration:

$$1s^22s^22p^63s^23p^5$$
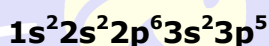
^{37}Cl

Electronic configuration:

$$1s^22s^22p^63s^23p^5$$
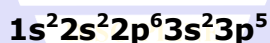
Q.15: In which block, group and period in the periodic table where would you place each of the following elements with the following electronic configuration?
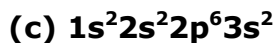
(a) $1s^22s^1$

Block= s-block
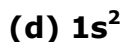
Group= IA

(b) $1s^22s^22p^5$

Block= p-block

Group= VIIA

Period= 2

(c) $1s^2 2s^2 2p^6 3s^2$

Block= s-block

Group= IIA

Period= 3

(d) $1s^2$

Block= s-block

Group= VIIIA

Period= 1.

THINK TANK

Q1 what types of elements have the highest ionization energies and what types of elements have the lowest ionization energies?

Ans with reference to trend of ionization energy going across a period in periodic table ionization energy increases. Therefore elements in the upper right of the periodic table have the highest ionization energy. The alkali metals Group IA have the lowest ionization energy and the noble gases Group VIIIA the highest.

Q2 Two atoms have electronic configuration $1s^2 2s^2 2p^6$ and $1s^2 2s^2 2p^6 3s^1$.The ionization energy of one is 20801kj/mol and that of the other is 496 kj/mol. Match each ionization energy with one of the given electronic configuration. Give reason for your choice.

with reference to trend of ionization energy going across a period in periodic table ionization energy increases. The alkali metals Group IA have the lowest ionization energy and the noble gases Group VIIIA the highest.

The electronic configuration $1s^2 2s^2 2p^6$ shows the noble gas Group VIIIA since noble gases have the highest ionization energy therefore in this case the value of ionization energy will be 20801kj/mol. The electronic configuration $1s^2 2s^2 2p^6 3s^1$ shows the alkali metals Group IA. Since alkali metals have the lowest ionization energy will be 496 kj/mol.

Q3 Use the second member of each group from Group IA, IIA and VIIA to show that the number of valence electron on an atom of the element is same as its group number.

IA	IIA	VIIA
Li	Mg	Cl
$2s^1$	$3s^2$	$3s^2 3p^5$

Q4 Letter A,B,C,D,E,F indicates elements in the following figure:

IA								VIIIA
	IIA		IIIA	IVA	VA	VIA	VIIA	
						C		
A				B				
	D				E			
							F	

a.   Which elements are in the same periods?

Ans Elements A and B are in the same periods i.e. period number 3. Elements D and E are in the same periods i.e. period number 4.

b.   Write valence shell electronic configuration of element D.

ANS: As element D lies in group IIA therefore valence shell configuration is $4s^2$.

c.   Which elements are metals ?

Ans: Elements A group IA and D group IIA are metals as they represent alkali and alkaline earth metals respectively.

d.   Which elements can lose two electrons?

Ans: Element D GROUP IIA can lose two electrons because element D contain two electrons in its valence shell.

e.   In which group E is present?

Ans: Element E is present in group VA.

f.   Which of the element is halogen?

Ans: Element F is halogen because it lies in group VIIA.

g.   Which element will form dipositive cation?

Ans: The element D form dipositive cation +2 because it lies in group IIA and can lose two electrons.

h.   Write electronic configuration of element E.

Ans: Element atomic number is 33 and electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6\ 4s^2\ 3d^{10}\ 4p^3$

i.   Which two elements can form ionic bond?

Ans: Elements A and D can form ionic bond because element A belongs to group IA element D belongs to group IIA. Group IA and IIA can loss electrons in their valence shell easily due to low ionization energy.

j.   Can element C form C_2 molecule?

Ans: Yes, element C can form C_2 molecule. In this case C belong to group VIA .The name of element is Oxygen O .The molecule of oxygen is represented by O_2.

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k. **Which element can form covalent bonds?**

Ans: Elements C and F can form covalent bonds. Element C is Oxygen. It forms double covalent bond. Element F belongs to group VIIA and it is iodine and it also form single covalent bond.

l. **Is element F a metal or non-metal?**

Ans. The element F is non metal. Element F belongs to group VIIA and it is iodine and it also form single covalent bond.

Q5 Electronic configurations of four elements are given below:

a. $1s^2 2s^1$

b. $1s^2 2s^2 2p^5$

c. $1s^2 2s^2 2p^6 3s^2$

d. $1s^2$

Which of these elements is

i) An alkali metal --------------------------------------- a

ii) An alkaline earth metal----------------------------- c

iii) A noble gas -- d

iv) A halogen -- b

Q6   In what region of the periodic table you will find elements with relatively

a) **High ionization energies**

Ans with reference to trend of ionization energy going across a period in periodic table ionization energy increases. Going down a group in a periodic table the ionization energy decreases. Therefore elements in the upper right of the periodic table have the highest. That would be Helium, He.

b) **Low ionization energies**

The alkali metals Group IA have the lowest ionization energy and the noble gases Group VIIIA the highest.

CHAPTER#4

Self assessment 4.1:

**Q;Find the number of electrons in valence shell of the following atoms using periodic table.**

(a) Silicon: valence electrons =4

(b) Sulphur: valence electrons =6

(c) Bromine: valence electrons =7

(d) Argon: valence electrons =8

(e) Potassium: valence electrons =1

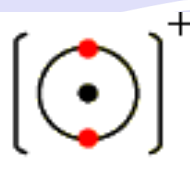**(f) Nitrogen** : valence electrons =5

Self assessment 4.2:

Q;   Describe the formation of cations for the following metal atom.

(a)Li (At.No3):

Li

E.C: $1s^2 2s^1$ $\xrightarrow{-1e}$ **Li^{+1}:** $1s^2$
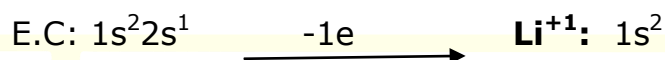
lithium atom   lithium ion
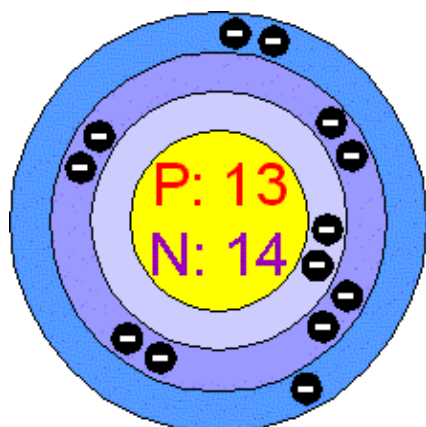Li   2,1   Li$^+$ [2]$^+$

Explanation:

- **It belongs to group number 1A.**
- **It has 1 electron in its valence shell.**
- **It is metal.**
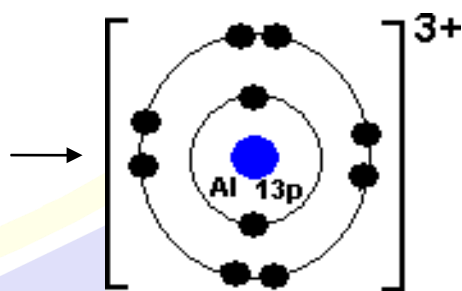- **Li will lose 1 electron to complete its duplet**

(b)Al (At.No 13):

E.C: $1s^2 2s^2 2p^6 3s^2 3p^1$ $\xrightarrow{-3e}$ **Al^{+3}:** $1s^2 2s^2 2p^6$

37

Aluminium   **Aluminium ion**
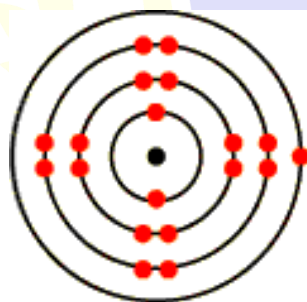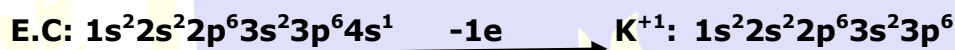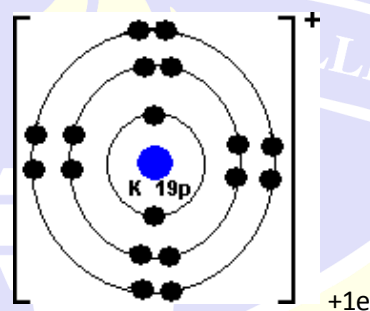

+3e

Explanation:

• **Aluminium belongs to group no 3A.**

• **It has 3 electrons in its valence shell.**

• **It is a metal.**

• **It will lose 3 electrons to complete its octet.**

Q.2: Represent the formation of cation for the followings metals. Using electron dot structures.

(a) $_{19}$K

E.C: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ ——**-1e**——→ **K^{+1}: $1s^2 2s^2 2p^6 3s^2 3p^6$**

+1e

potassium   **potassium ion**

(b) $_{20}$Ca

E.C: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ **-2e** ——→ **Ca^{+2}:** $1s^2 2s^2 2p^6 3s^2 3p^6$

Calcium

+2e
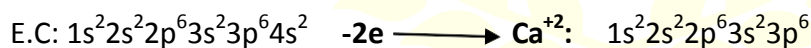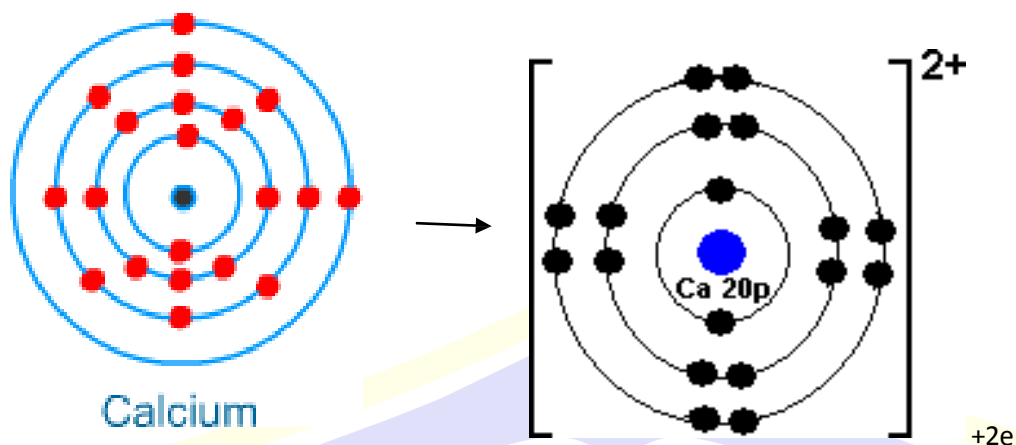
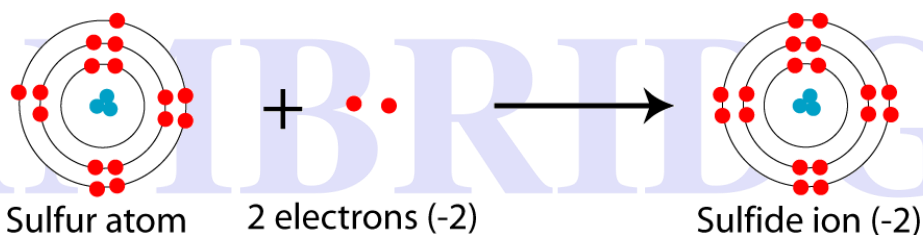## Self assessment 4.3:

Q.1: Describe the formation of anions by the following non metals?

(a) sulphur (At.No16):

E.C: $1s^2 2s^2 2p^6 3s^2 3p^4 + 2e$ $\xrightarrow{+2e}$ $S^{-2}: 1s^2 2s^2 2p^6 3s^2 3p^6$

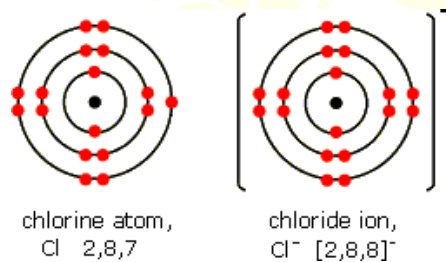
Sulfur atom   2 electrons (-2)   Sulfide ion (-2)

Explaination:

- **Sulphur is a non metal.**

- **It belongs to group VIA.**

- **It has six electrones in its valence shell.**

- **It needs 2 electrones to complete its octet.**

(b)Cl (At.17):

E.C: $1s^2 2s^2 2p^6 3s^2 3p^5$ $\xrightarrow{+1e}$ $Cl^{-1}: 1s^2 2s^2 2p^6 3s^2 3p^6$

chlorine atom,   chloride ion,
Cl   2,8,7   Cl⁻ [2,8,8]⁻
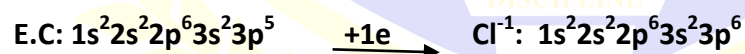
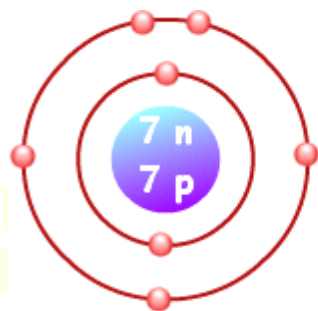## Explaination:

- **Cl is a non metal.**

39

- **It belongs to group VIIA.**

- **It has 7 electrons in its valence shell.**

- **It needs 1 more electrons to complete its octet.**

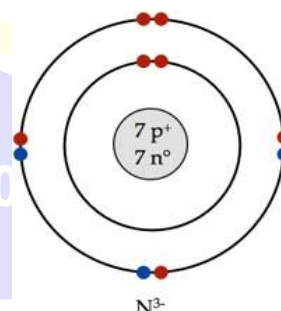**Q.2: Represent the formation of following non metals using electron dot and cross structure.**

(a)$_7$N

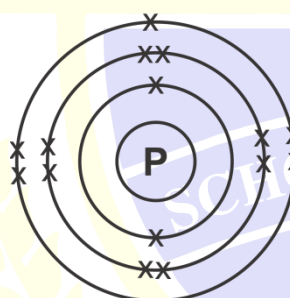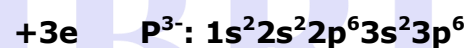E.C: $1s^2 2s^2 2p^3$ +3e N^{-3} $1s^2 2s^2 2p^6$

Nitrogen
$^{14}_{7}N$ + 3e

N^{3-}

(b) $_{15}$P

E.C: $1s^2 2s^2 2p^5 3s^2 3p^3$ +3e P^{3-}: $1s^2 2s^2 2p^6 3s^2 3p^6$

(c) $_1$H

E.C: $1s^1$ +1e H^{-1} $1s^2$
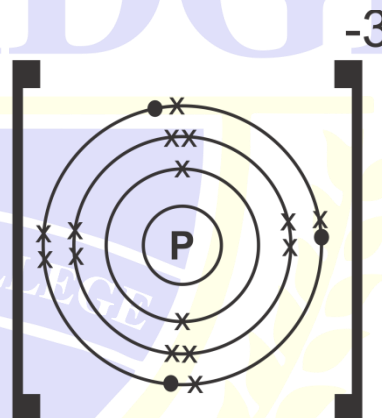
Self assessment 4.4:

Q.1: For the following pairs of atom use electron dot and cross structures to write the equation for the formation of ionic compounds.

(a) Mg and O

Mg. E.C: $1s^2 2s^2 2p^6 3s^2$ $\xrightarrow{-2e}$ Mg^{+2}: $1s^2 2s^2 2p^6$

O. E.C: $1s^2 2s^2 2p^4$ $\xrightarrow{+2e}$ O^{-2}: $1s^2 2s^2 2p^6$

Ionic compound:

$Mg^{+2} + O^{-2} \longrightarrow MgO$

Atomic structure:

Ionic Bond
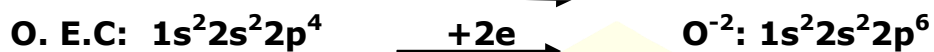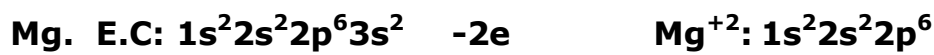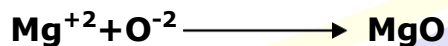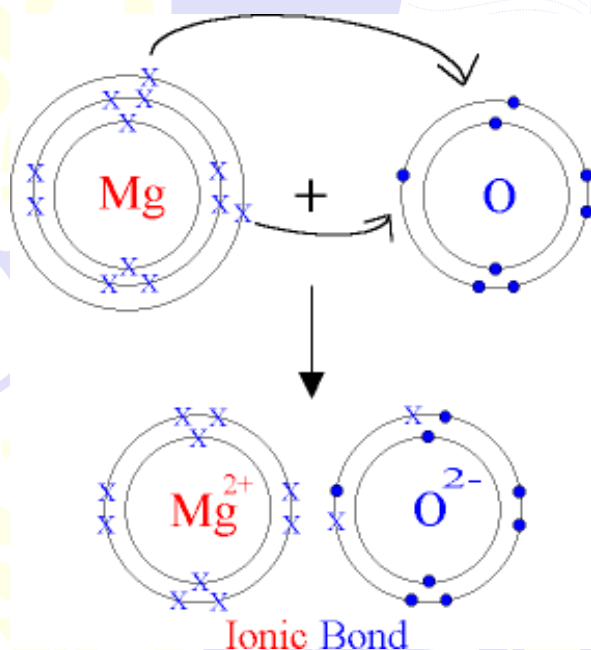
Explanation:

- Mg is a metal, while O is a non metal.

- Mg belongs to group IIA it has 2 electrons in its valence shell.It will lose 2 electrons to form $Mg^{+2.}$

- O belongs to group VIA, it has 6 valence electrons. It will gain 2 valence electrons to form O^{-2}.

- Every Mg^{+2} need O^{-2} ion to form MgO.

(b) AlCl$_3$

$_{13}Al$. E.C: $1s^2 2s^2 2p^6 3s^2 3p^1$ $\xrightarrow{-3e}$ Al^{+3}: $1s^2 2s^2 2p^6$

$_{17}Cl$ E.C: $1s^2 2s^2 2p^6 3s^2 3p^5$ $\xrightarrow{+1e}$ Cl^{-1}: $1s^2 2s^2 2p^6 3s^2 3p^6$

Ionic equation:

$Al^{+3} + 3Cl \longrightarrow AlCl_3$

Explanation:

• Al is a metal, while Cl is a non metal.

• Al belongs to group IIIA, it has 3 electrons in its valence shell.It will loses 3 electrons to form Al^{+3}.

• Cl belongs to group VIIA, it has 7 electrons in its valence shell.It will gain one electron to form Cl^{-1}

• For every Al^{+3} we need $3Cl^{-1}$ ion to form $AlCl_3$

Self assessment 4.5:

Q. Recognize the following compounds as havingionic bonds.

(a) KCl

$_{19}K$: E.C: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ $\xrightarrow{-1e}$ K^{+1}: $1s^2 2s^2 2p^6 3s^2 3p^6$

$_{17}Cl$: E.C: $1s^2 2s^2 2p^6 3s^2 3p^5$ $\xrightarrow{+1e}$ Cl^{-1}: $1s^2 2s^2 2p^6 3s^2 3p^6$

Explanation:

• K is a metal while Cl is a non metal.

• K belongs to group IA, it has one valence electron.It will lose 1 electrons to form K^{+1}.

• Cl belongs to group VIIA,it has 7 valence electrons. It will gain one ekectron to form Cl^{-1}.

• For every K^{+1} we need Cl^{-1} ion to form KCl.

Ionic equation:
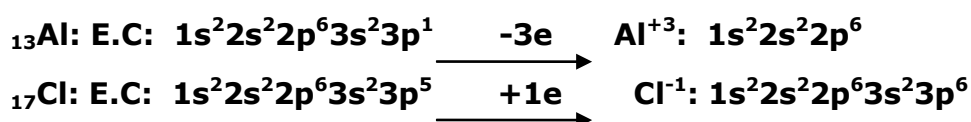
K^{+1} + Cl^{-1} KCl

(b) $AlCl_3$

$_{13}Al$: E.C: $1s^2 2s^2 2p^6 3s^2 3p^1$ $\xrightarrow{-3e}$ Al^{+3}: $1s^2 2s^2 2p^6$

$_{17}Cl$: E.C: $1s^2 2s^2 2p^6 3s^2 3p^5$ $\xrightarrow{+1e}$ Cl^{-1}: $1s^2 2s^2 2p^6 3s^2 3p^6$

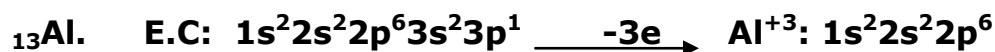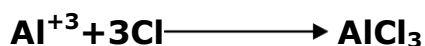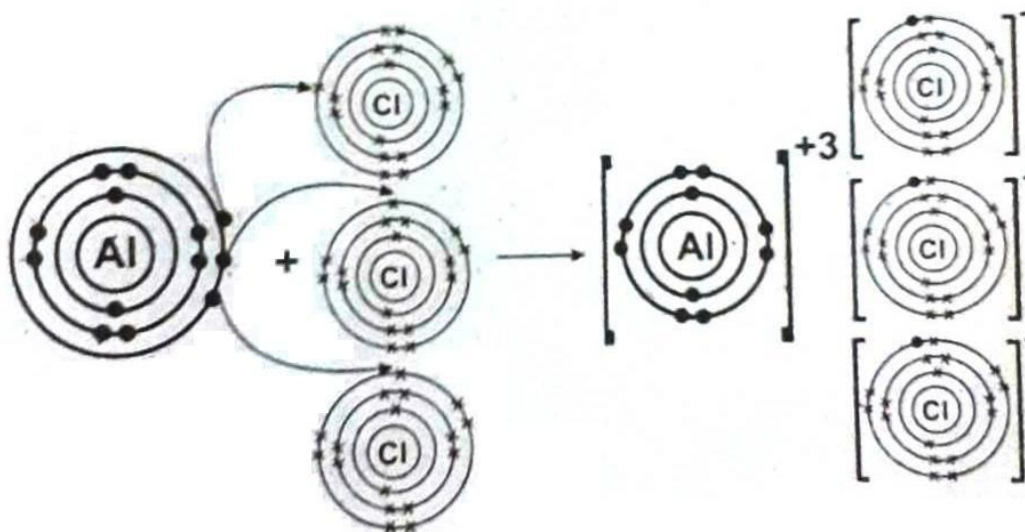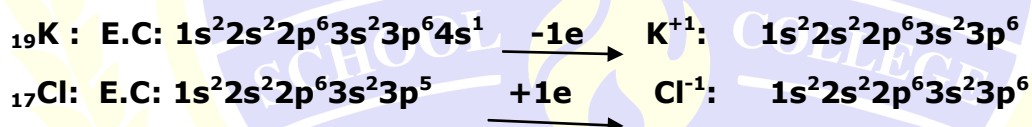**Explanation:**

• Al is a metal while Cl is a non metal.

• Al belongs to group IIIA,it has 3 electrons in its valence shell. It will lose 3 electrons to fom Al^{+3}.

• Cl belongs to group VIIIA, it has 7 electrons in its valence shell. It will gain 1 electron to form Cl^{-1}.

• For every Al^{+3} we need $3Cl^{-1}$ ion to form $AlCl_3$.

Ionic equation:

$Al^{+3} + 3Cl^{-1}$ $AlCl_3$

(c) MgF$_2$

$_{12}Mg$: E.C: $1s^2 2s^2 2p^6 3s^2$ $\xrightarrow{-2e}$ Mg^{+2}: $1s^2 2s^2 2p^6$

$_9F$:   E.C: $1s^2 2s^2 2p^5$ $\xrightarrow{+1e}$ F^{-1}: $1s^2 2s^2 2p^6$
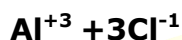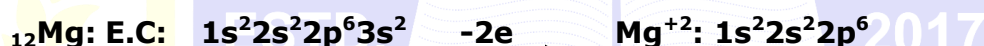
Explanation:

• Mg is a metal while F is a non metal.

• Mg belongs to group IIA,it has 2 electrons in its valence shell. It will lose 2 valence electron to form Mg^{+2}.

• F belongs to group VIIA, it has 7 electrons in its valence shell. It will gain 1 electron to form F^{-1}.

• For every Mg^{+2} we need $2F^{-1}$ ion to form MgF_2.

Ionic equation:

$Mg^{+2} + 2F^{-1}$ MgF_2
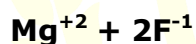
<u>Self assessment 4.6:</u>

Q: Draw electron dot and cross structure for the following mollecules.

(a)NH$_3$, that Is used to manufacture urea.

Electron dot and cross structure:
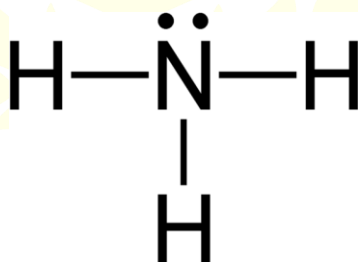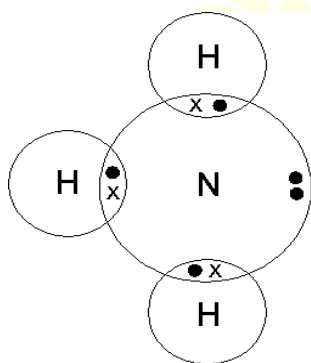
(b) CCl$_4$, a dry cleansing agent.

Electron dot and cross structure:
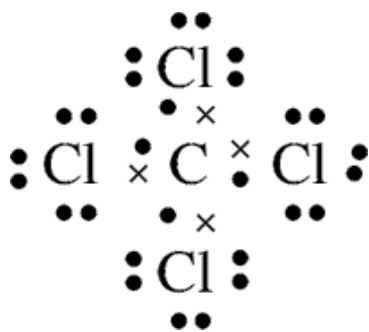
(c) SiCl₄

Electron dot and cross structure:
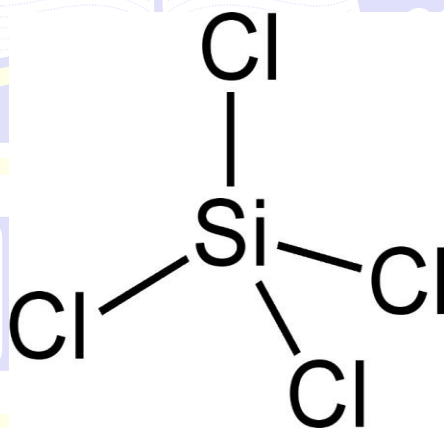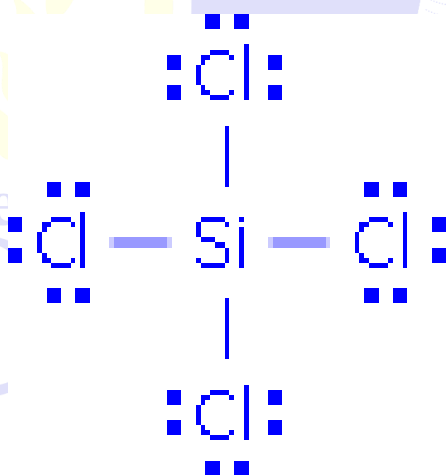
(d) H₂S, a poisonous gas.
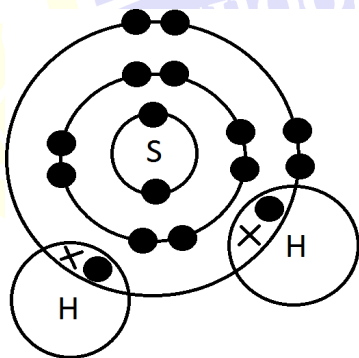
Self assessment 4.7:

Q: Draw electron cross and dot structure for the following mollecules.

(a)CS₂, an organic solvent that dissolves sulphur,phosphorus etc.
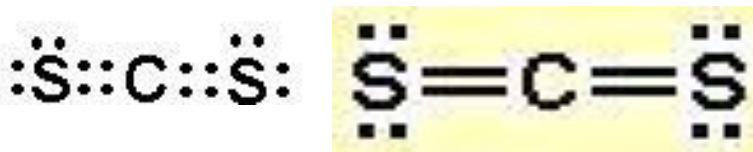
(b) N₂, a compound of air.

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$$N \equiv N$$
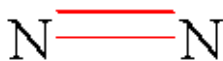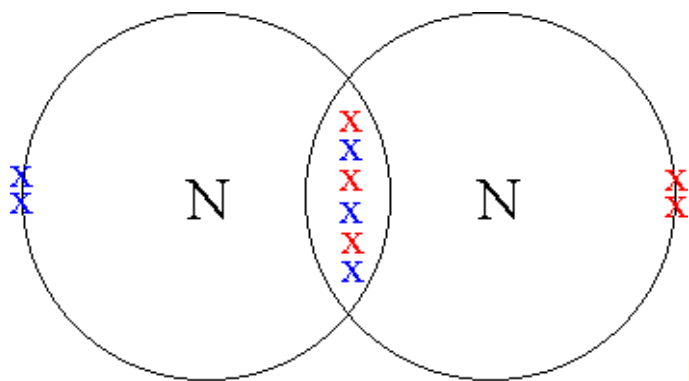
Review questions

Q.8: Find the number of valence electrons in the following atoms using the periodic table.

(1) Boron:Belongs to group IIIA

V.E: 3

(2) Neon:Belongs to group VIIIA

V.E: 8

(3) Rubidium: Belongs to group IA

V.E: 1

(4) Barium: Belongs to group IIA

V.E: 2

(5) Arsenic: Belongs to group VA

V.E: 5

Q.14: An atom of an element has At.No 9 and M.No 19

(a) State the number of protons and neutrons in the nucleus of this atom P=9; N=10

(b) State the number of electrons in this atom e=9

(c) Show with electron dot diagram the formation of ions in the reaction of this atom with sodium atom.

Sodium   Fluorine

Ionic equation:

$$Na^+ + X^- \longrightarrow NaX$$
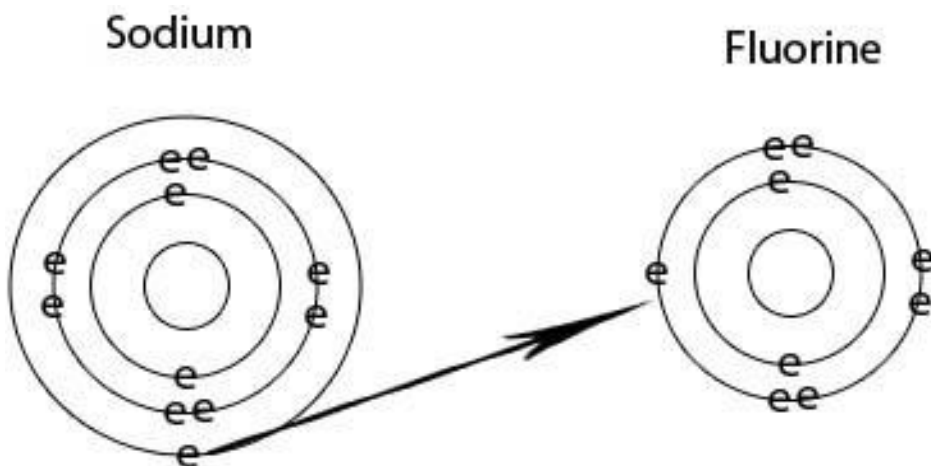
Q.12: Draw dot and electron structure of the following.

1) K and Cl:

- K is a netal and Cl is a non metal.

- K will lose one electrons to form K^{+1} and Cl gain one electron to form Cl^{-1}.
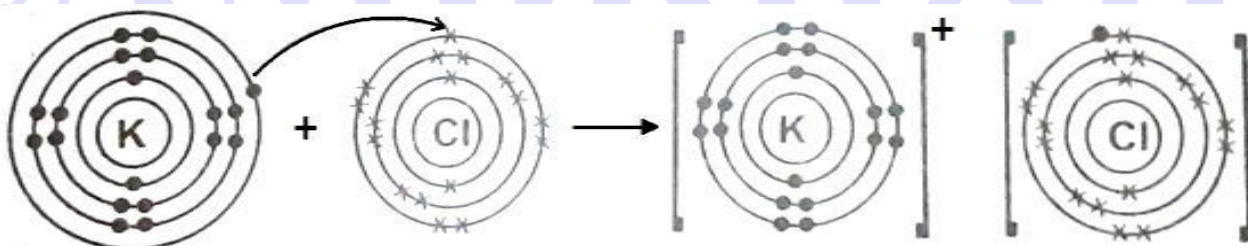
b) Ca and S

- Ca is a metal and S is a non metal.

- Ca will lose two electrons to form Ca^{+2} and S will gain 2 electrons to form

- $S^{-2.}$

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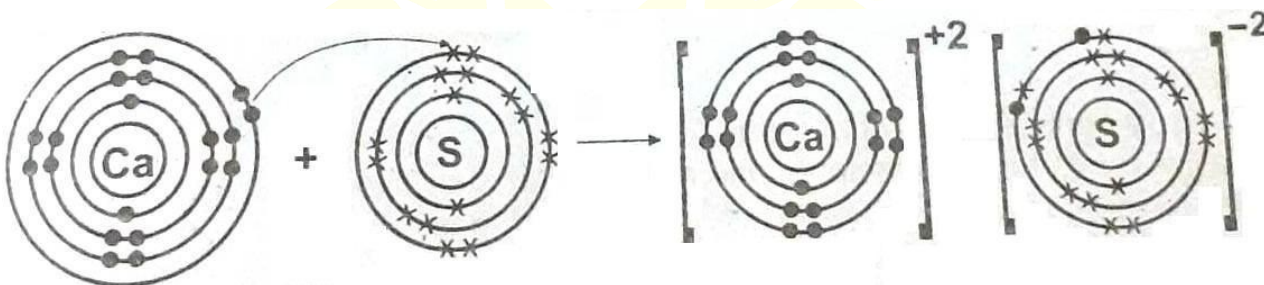
Q.9: Represent the formation of cations for the following metal dot and cross structure.

a) $_{13}$**Al:**

E.C: $1s^2 2s^2 2p^6 3s^2 3p^1$ **-3e**   **Al^{+3}: $1s^2 2s^2 2p^6$**

3 electrons are lost

13+   13+

Aluminium atom   Aluminium ion

b) $_{38}$**Sr**

E.C: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2$ **-2e**   **Sr^{+2};**
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$

38: Strontium   2,8,18,8,2

38P
50N

2+

C) $_{56}$**Ba**

E.C: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2$ **-2e**

Ba^{+2} ; $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6$
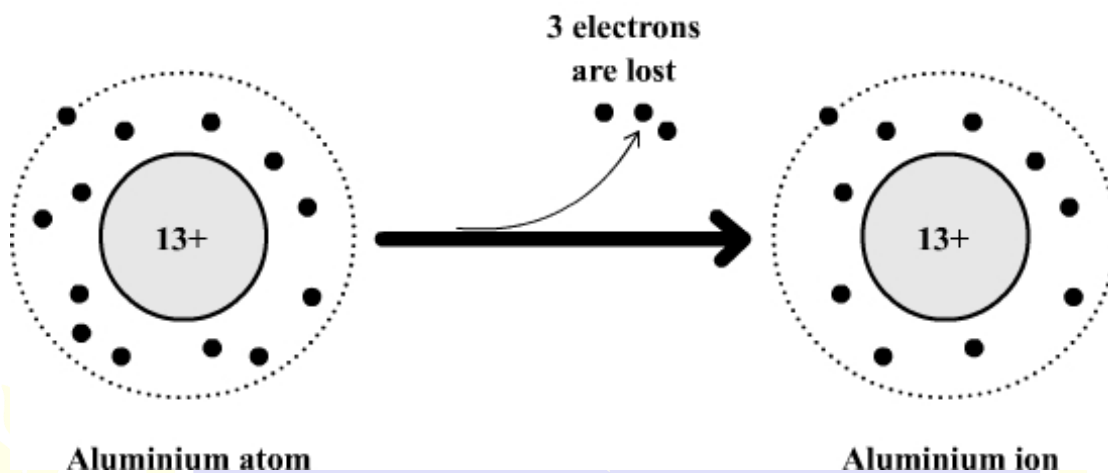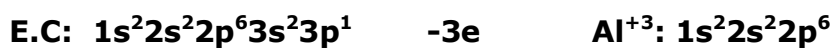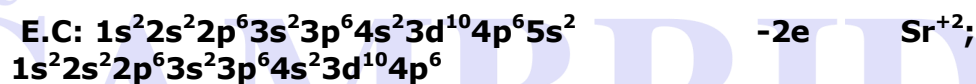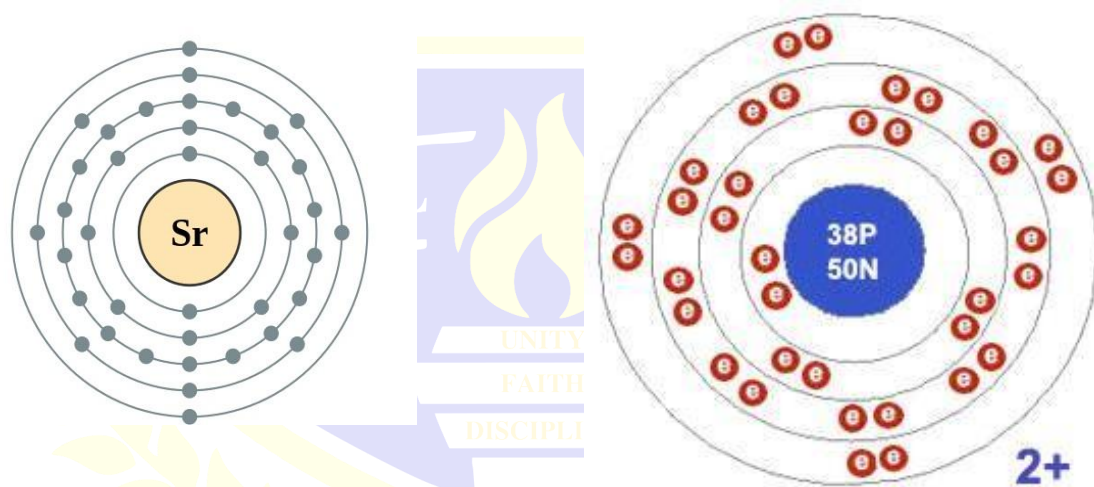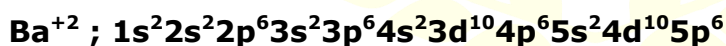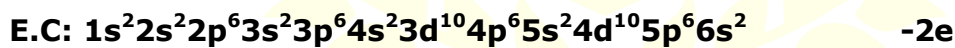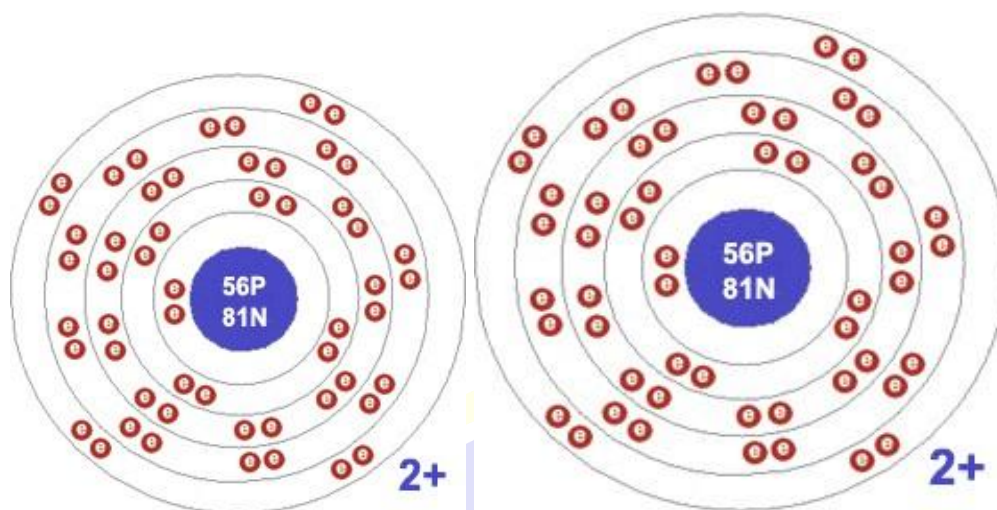
Barium   Barium ion

Q.13: Recognize the following compound as ionic bonds.

(a) MgCl$_2$;

- Mg is a metal and Cl is a non metal.

- Mg belongs to group IIA and has 2 valence electrons.It will loses 2 electrons to form Mg^{+2} ion.

- Cl belongs to group VIIA and has 7 valence electrons. It will gain 1 electron to form Cl^{-1}.

- In this way both the atom achieve the nearest noble gas configuration.

- Chemical formula of the resulting chemical is MgCl$_2$.

- MgCl$_2$ is aionic compound

- For every Mg^{+2} ion we need 2 Cl^{-1} ion.

(b)   KBr:

- K is a metal and Br is a non metal.

- K belongs to group IA and has 1 valence electron. It will lose 1 electron to   form K^{+1} ion.

- Br belongs to group VIIA and has 7 valence electrons. It will gain one electron to form Br^{-1}ion.

- In this way both atom achieve the nearest noble gas configuration.

- Chemical formula of the resulting molecule is KBr.

- Therefore KBr is a ionic compound.

- For every K^{+1} ion we need 1Br^{-1} ion.

(c)   NaI:

- **Na is a metal and I ia non metal.**

- **Na belongs to group IA and has 1 valence electron. It will lose one electron and form Na^{+1}ion.**

- **I belongs to group VIIA and has 7 valence electron. It will gain one electron and form I^{-1}ion.**

- **In this way both atom achieve the nearest noble gas configuration.**

- **Chemical formula of the resulting molecule is NaI.**

- **Therefore NaI is an ionic compound.**

- **For every Na^{+1} ion we need I^{-1} ion.**

Think Tank

Q1. Magnesium oxide is a compound made up of magnesium ions and oxide ions.
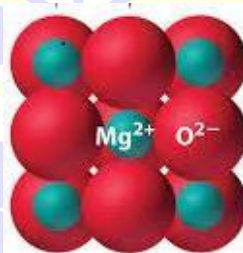
MgO

A) What is the charge on these ions?

Ans: Mg^{+2} and O^{-2}

B) How these ions get these charges.

Ans: Mg^{+2} ion is formed by losing two electrons whereas O^{-2} ion is formed by gaining two electrons.

C) Show with electron cross-dot diagrams the formation of these ions.

Ans : Mg (At.No 12):

Explaination:

- **Magnesium belongs to group no 2A.**

- **It has 2 electrons in its valence shell.**

- **It is a metal.**

- **It will lose 2 electrons to complete its octet.**

E.C: $1s^2 2s^2 2p^6 3s^{2}$ $\xrightarrow{-2e}$ **Mg^{+2}:** $1s^2 2s^2 2p^6$

Magnesium   **Magnesium ion**

Oxygen (At.No 8):

Explaination:

- **Oxygen belongs to group no 6A.**

- It has 6 electrons in its valence shell.

- It is a non metal.

- It will gain 2 electrons to complete its octet.

E.C: $1s^2 2s^2 2p^4 + \overset{2e^-}{\longrightarrow}$ $O^{-2}: 1s^2 2s^2 2p^6$

      Oxygen   Oxygen ion

Ionic Bond
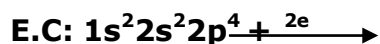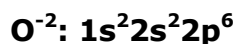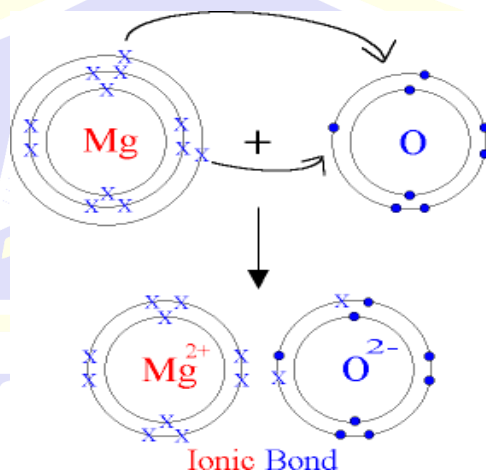
Q2. The diagrams below show the electronic structures of an atom of calcium and an atom of oxygen. Draw structures of the ions that are formed when these atoms react.

Ans:

Calcium   +   8: Oxygen   2,6
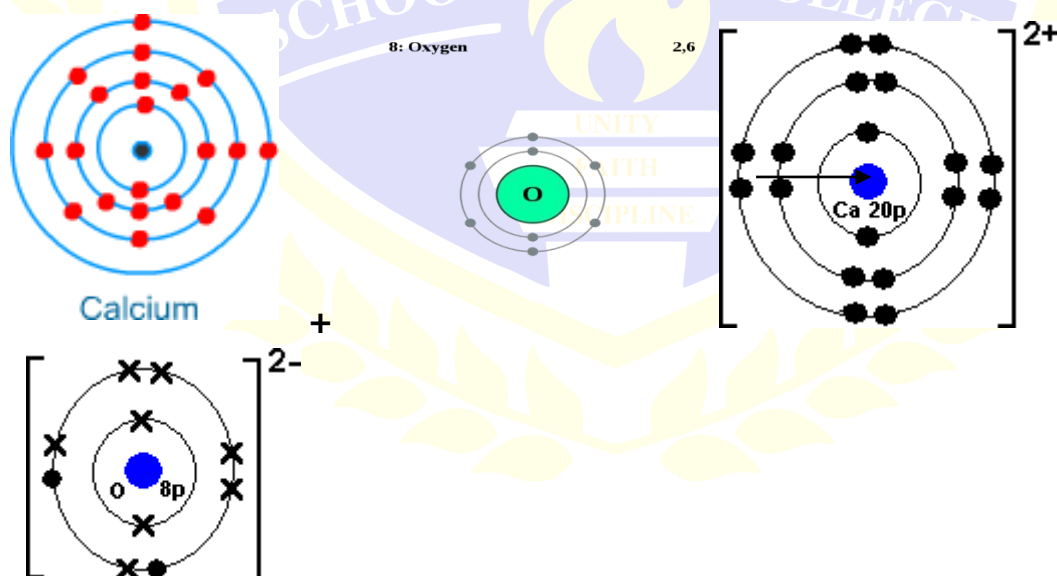
(a). Draw electron cross and electron dot structures for the following molecules:

(i) $COCl_2$ a poisonous gas called phosgene that has been used in world war II.

(ii) $HOCl$ is unstable, decomposes to liberate atomic oxygen that makes $HOCl$ a strong oxidizing agent.
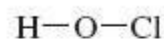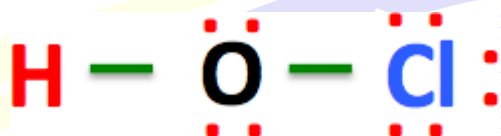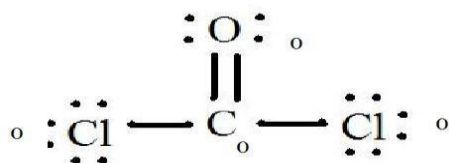
Q.10   Q.11

Q4: The table below shows the properties of four substances.

substances	melting point/°C	electrical conductivity in aqueous solution	electrical conductivity in molten state
A	High	Nil	Nil
B	High	Nil	Good
C	Low	Nil	Nil
D	High	Good	Good

A) Which substance is a metal? D

B) Which substance is an ionic compound? B

C) Which substance is a covalent compound? C

D) Which substance is a non metal? A

Q5 Electronic configuration of two elements X and Y are given below

$X=1s^2 2s^2 2p^6 3s^2$

$Y=1s^2 2s^2 2p^4$
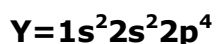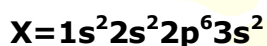
Which of the following compounds is likely to form when X and Y react? Explain.

a) a covalent compound of formula XY_2

b) an ionic compound of formula XY_2

c) an ionic compound of formula XY

d) an ionic compound of formula X_2Y

Q6 The following figure shows the electron dot and cross diagram of molecule AB$_2$.Which of the elements could be A and B?

Ans:
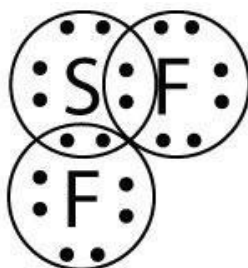
Q7: What is the total number of shared electrons in a molecule of CO$_2$?

Ans: The O atoms have complete octets around them, but the C atom has only four electrons around it. The way to solve this problem is to make a double bond between carbon and each O atom:

Each O atom still has eight electrons around it, but now the C atom also has a complete octet.

(ii) The salt that give violet fumes having pungent odour. Test these vapours with starch paper, it will turn blue. This indicates $\longrightarrow$ I$^-$ ion.

Q.5: An iron bar is to be silver plated which metal would be the anode and which the cathode?

Ans: An iron bar is to be silver plated. In this process iron bar will be cathode and silver will be anode.

Chapter 5 PHYSICAL STATES OF MATTER

SELF ASSESMENTS

Self-Assessment Exercise 5.1:

1. A student obtained following data in an experiment at 20°C.

P (atm)	V(dm3)
0.350	0.707
0.551	0.450
0.762	0.325
0.951	0.261
1.210	0.205

Explain pressure-volume relationship using this data and the Boyle's law.
Ans: Pressure-volume relationship

Pressure-volume relationship P (atm)	V(dm3)	PV=K (atm.dm3)
0.350	0.707	0.350 × 0.707= 0.247
0.551	0.450	0.551 × 0.450= 0.247
0.762	0.325	0.762 × 0.325= 0.247
0.951	0.261	0.951 × 0.261= 0.247
1.210	0.205	1.210 × 0.205= 0.247

The product PV is constant which means volume of a gas is inversely proportional to pressure on the gas. Thus the calculated results agree with the pressure-volume relationship according to Boyle's law.

2. Ammonia gas is used as refrigerant. 0.0474 atm pressure is required to change 2000cm3 sample of ammonia initially at 1.0 atm to 4.22 dm3 at constant temperature. Show that this data satisfy Boyle's law.

Ans :

P1 = 1.0 atm

P2 = 0.474 atm

V1 = 2000 cm3 :: 2000cm3 /1000 = 2 dm3

V1 = 4.22 dm3

P (atm)	V(dm3)	PV=K (atm.dm3)
0.474	2.0	1.0 2.0 = 2.0
1.0	4.22	0.474 4.22 = 2.0

The product PV is constant which means volume of a gas is inversely proportional to pressure on the gas. Thus the calculated results agree with the pressure-volume relationship according to Boyle's law.

3

Self-Assessment Exercise 5.2:

1. A chemist obtained data shown in the table below in an experiment at 1 atm.

Temperature °C	Volume (cm³)
25	117.5
30	119.4
35	121.3
40	123.2

Explain the Volume-Temperature relationship using Charles's law.

Ans:

Volume-Temperature relationship

Temperature °C	Volume (cm³)	Temperature K	V/T
25	117.5	298	117.5/298 = 0.394
30	119.4	303	119.4/303 = 0.394
35	121.3	308	121.3/308 = 0.394
40	123.2	313	1273.2/313=0.394

The ratio V/T is constant. Thus volume of the gas is directly proportional to absolute temperature as stated by the Charles law.

2. A bacterial culture isolated from sewage produces 36.4cm3 of methane(CH4) gas at 27oC and 760mmHg. This gas occupies 33.124 cm3 at 0oC and same pressure. Explain Volume-Temperature relationship from this data.

Ans:

T1 = 27oC

T2 = 0oC

V1 = 36.4 cm3

V1 = 33.124 cm3

Volume-Temperature relationship

Temperature °C	Volume (cm³)	Temperature K	V/T
27	36.4	300	36.4 / 300 = 0.121
0	33.124	273	33.124/273=0.121

The ratio V/T is constant. Thus volume of the gas is directly proportional to absolute temperature as stated by the Charles law.

3. A perfect elastic balloon filled with helium gas has a volume of 1.25 103 dm3 at 1.0 atm and 25oC on ascending to a certain altitude where temperature is 15oC, the volume of balloon becomes 1.208 10 dm3. Show this data satisfies Charles's Law.

4

Ans:

T$_1$ = 25°C

T$_2$ = 15°C

V$_1$ = 1.25 x 10^3 dm^3

V$_1$ = 1.208 x 10^3 dm^3

Volume-Temperature relationship

Temperature ^{o}C	Volume (dm^3)	**Temperature** K	V/T
25	1.25 103	298	1.25 x 10^3/ 298 = 4.19
15	1.208 103	288	1.208 x 10^3/288 = 4.19

The ratio V/T is constant. Thus volume of the gas is directly proportional to absolute temperature as stated by the Charles law.

Self-Assessment Exercise 5.3:

Give reasons:

1. When you put nail polish remover on your palm, you feel a sensation of coldness.

Ans: Evaporation causes cooling. When we put nail polish remover on our palm, evaporation takes place during which high energy molecules leave our palm and low energy molecules are left behind due to which sensation of coldness is felt.

2. Wet clothes dry quickly in summer than in winter.

Ans: Evaporation increases with increase in temperature. In summer, the temperature of atmosphere is greater than that of winter due to which water molecules present on clothes take energy from atmosphere and evaporate faster.

Self-Assessment Exercise 5.4:

Look at the following figure and predict the boiling points of four liquids at normal atmospheric pressure.

Ans: Boiling points:

Chloroform   80°C

Ethanol   78°C

Water   100°C

Ethanoic acid   120°C

Self-Assessment Exercise 5.5:

1. The boiling point at top of Mount Everest in 70°C while at Murree 98°C. Explain this difference.

Ans: Boiling point of a liquid is the temperature at which vapour pressure of a liquid becomes equal to atmospheric pressure.

At Mount Everest, the atmospheric pressure is only 34kPa, and water needs less energy to attain this vapour pressure. At 70°C vapor pressure of water becomes 34kPa. So water boils at 70°C.

Ar murree, the atmospheric pressure is 93kPa, and water needs more energy to attain this vapour pressure. At 98oC vapor pressure of water becomes 93kPa. So water boils at 98°C.

2. If you try to cook an egg while camping at an elevation of 0.5km in the mountain, you will find that it takes longer than it does at home. Explain why?

Ans: When we go at elevation, atmospheric pressure decreases. As a result liquids water boils at temperature less than 100°C. So if we cook egg at an elevation of 0.5km, temperature of boiling water is less. That's why it will take longer time than it does at home.

Self-Assessment Exercise 5.6:

Q: Sodium chloride, an ionic crystal has a high melting point of 801°C. Whereas molecular solids such as ice has relatively low boiling point of 0°C. Explain this difference.

Ans: Melting point depends upon the strength of the attractive forces that hold particles together in the fixed position. In sodium Chloride, there are strong forces of attraction between opposite charged Na+ and Cl- ions which is called ionic bond. While in ice, there are dipole-dipole intermolecular forces of attraction between water molecules which are quite weaker than that of ionic bond present in Sodium Chloride. That's why melting point of sodium chloride is higher than ice.

Self-Assessment Exercise 5.7:

1. Quartz is a crystalline form of silicon dioxide (SiO_2). It is hard, brittle and colourless solid. When quartz is heated above its melting point (about 1600°C) and cooled rapidly, an amorphous solid called Quartz glass results.

The figure below shows two dimensional representations of Quartz glass and Quartz crystal. Identify each. Give reasons.

Ans: The figure "a" shows Quartz crystal and "b" show Quartz glass because in figure a, there is an ordered arrangement of particles while figure b lacks the ordered arrangement of its particles.

2. Differentiate between amorphous and crystalline solids by writing appropriate sentences in the boxes

CRYSTALLINE SOLIDS	AMORPHOUS SOLIDS
Have repetitive arrays of particles.	Do not possess well defined arrangements of particles.
Possess well defined arrangements of particles.	Have no repetitive arrays of particles.
Have sharp melting point.	Melt over a wide range of temperature.

Self-Assessment Exercise 5.8:

Copy and make comparison of physical stares of matter by writing appropriate sentences in the empty boxes.

SOLID	LIQUID	GAS
Have a definite shape and volume.	Do not have definite shape but have definite volume.	Do not have definite shape and volume.
Particles are closely packed together and have strong intermolecular forces.	Particles are not closely packed together and have strong intermolecular forces.	Particles are not closely packed together and they don't have strong intermolecular forces.
Particles don't have translational motion. They only vibrate about their mean position.	Particles moves about freely and do not have random motion.	Particles moves about freely and random in all directions.

REVIEW QUESTIONS

Q # 2: Give short answers.

1. Explain why volume of a gas decreases by increasing pressure on it at constant temperature?

Ans : There are large spaces between the gas molecules. By increasing pressure distance between the gas molecules decreases as gas molecules come closer to each other. As a result volume of gas decreases.

2. How does temperature affect the vapour pressure of a liquid?

Ans: When temperature of a gas is increased, the average kinetic energy of gas molecules also increases, so the gas molecules exert more pressure on walls of container. As a result, volume of gas increases to restore that pressure.

3. Water boils in pressure cooker at 120oC. Why?

Ans: Boiling point of a liquid depends upon the external pressure. Water boils at 100oC when external pressure is 1atm. In pressure cooker, external pressure is 2atm. Due to which water boils at 120oC.

4. Is evaporation a cooling process?

Ans: Yes, evaporation is a cooling process. During evaporation, molecules having high kinetic energy leave the surface of liquid and molecules having low kinetic energy are left behind. As a result, temperature of the liquid decreases.

5. Can you make water boil at 70oC?

Ans: Boiling point of a liquid depends upon the external pressure. By decreasing external pressure, water can be boiled at lower temperature. Water boils at 70oC at Mount Everest where external pressure is only 34kPa. So by decreasing external pressure up to 34kPa, we can boil water at 70oC.

6. Express the pressure 400 mmHg in kPa.

Ans: We know that,

760mmHg = 101.125kPa

1 mmHg = 101.125kPa/760

400 mmHg = 101.125kPa/760 × 400 = 52.33 kPa

Hence, 400 mmHg = 53.33kPa

Q # 9 : Plots of vapour pressure versus temperature of four liquids are given in the following figure:

a. Find the boiling point of each liquid when atmospheric pressure is 1 atm.

Ans:

i. Chloroform 80°C

ii. Ethanol 78°C

iii. Water 100°C

iv. Ethanoic acid 120°C

b. At what temperature ethanol will boil when the atmospheric pressure is 51kPa?

Ans: Ethanol will boil at 60°C when the atmospheric pressure is 51kPa.

c. How can you make water to boil at 80°C?

Ans: Water can be boiled at 80°C if external pressure is 50kPa.

d. At what temperature chloroform will boil when external pressure is 50kPa?

Ans: Chloroform will boil at 60°C when external pressure is 50kPa.

e. Can you boil chloroform at 0°C?

Ans: Chloroform can be boiled at 0°C if external pressure is 10kPa.

f. Predict the boiling point of chloroform at 600mmHg.

Ans: We know that,

760mmHg = 101.125kPa

1 mmHg = 101.125kPa/760

600 mmHg = 101.125kPa/760 × 600 = 52.33 kPa

Hence, 600 mmHg = 80 kPa

According to the above figure, chloroform will boil at 57°C when external pressure is 600 mmHg.

Q # 11: Why does evaporation lowers the temperature of a liquid?

Ans: Yes, evaporation is a cooling process. During evaporation, molecules having high kinetic energy leave the surface of liquid and molecules having low kinetic energy are left behind. As a result, temperature of the liquid decreases.

Q # 12: The air in perfectly elastic balloon occupies 885 cm3, during the fall when temperature is 20oC. During the winter, the temperature on a particular day is -10oC, the balloon occupies 794.39 cm3 volume. If the pressure remains constant, show that the given data proves the volume temperature relation according to the Charles's law.

Ans:

Volume-Temperature Relationship

Temperature °C	Volume (cm^3)	**Temperature** K	V/T
20	885	293	885/293 = 3.02
-10	794.39	263	794.39/263 = 3.02

The ratio V/T is constant. Thus volume of the gas is directly proportional to absolute temperature as stated by the Charles law.

Q # 13: In the past, gas volume was used as a way to measure temperature using devices called gas thermometers. An experiment obtains following data from gas thermometer.

Volume (dm^3)	Temperature ^{o}C
2.7	0
3.7	100
5.7	300

Show that gas thermometer obtained results are according to Charles's Law.
Ans: Volume-Temperature Relationship

Volume (dm^3)	Temperature ^{o}C	**Temperature** K	V/T = k
2.7	0	273	2.7/273 = 0.0099
3.7	100	373	3.7/373 = 0.0099
5.7	300	573	5.7/573=0.0099

The ratio V/T is constant. Thus volume of the gas is directly proportional to absolute temperature as stated by the Charles law.

Q # 14: In the automobile engine the gaseous fuel-air mixture enters the cylinder and is compressed by a moving piston before it is ignited. If the initial cylinder volume is 900cm3, after the piston moves up, the volume is 90cm3. The fuel-air mixture initially has a pressure of 1.0 atm and final pressure is 11.0 atm. Do you think this change is according to the Boyle's law?

Ans:

Pressure-volume relationship

P (atm)	V(cm^3)	PV=K (atmdm^3)
1.0	900	900 × 1.0= 900
11.0	90	90 × 11= 990

No, this is not according to Boyle's Law as pressure-volume product is not constant for the given data.

Q # 15: A sample of neon is in a neon sign has a volume of 1500cm3 at a pressure 636 torr. The volume of a gas after it is pumped into the glass tube of the sign is 1213.74cm3, when it shows a pressure of 786 torr. Show that this data obeys Boyle's Law.

Ans: Pressure-Volume relationship

P (atm)	V(cm^3)	PV=K (atmdm^3)
1500	636	636 × 1500 = 954000
1213.74	786	1213.74 × 786 = 954000

The product PV is constant which means volume of a gas is inversely proportional to pressure on the gas. Thus the calculated results agree with the pressure-volume relationship according to Boyle's law.

Q # 16: instrumentation changes as science progresses, comments on it.

Reference : Textbook

THINK TANK

Q # 1: The following table shows the data collected from an experiment by a student.

Volume(dm³)	Pressure(mmHg)
400	353.5
320	442
240	589
200	589

Ans:

Do you think that the student collected the data carefully or carelessly? Explain

Ans:

Volume(dm³)	Pressure(mmHg)	PV = K
400	353.5	353.5 × 400 = 141,400
320	442	442 × 320 = 141,440
240	589	589 × 240 = 141,360
200	707	707 × 200 = 141,400

According to Boyle's law, Pressure-volume product must be a constant value. In above data, Pressure-volume product has some values which are not constant, which means student collected data carelessly.

Q # 2: The water level in an aquarium decreases slowly even though the tank does not leak. What change of state is occurring?

Ans: Water level in an aquarium decreases slowly due to evaporation. Even at room temperature, water molecules keep on escaping the water surface. As a result volume of water decreases.

Q # 3: What type of attractive forces do you expect between the molecules of HF and HCl?

Ans: Dipole-Dipole forces of attraction are present between the molecules of HCl and HF. Both molecules have polar covalent bonds. Cl and F has partial negative charge due to their high electronegativity while hydrogen is partial positively charged in both molecules. As a result, partial negatively charged end of one molecule attracts the partial positive charged end of other molecule creating dipole-dipole forces of attraction.

11

Q # 4: Name two substances that are solids at 25°C. Name the two substances that are liquids at 25°C.

Ans: Sucrose and sodium chloride are solids at room temperature while water and ethanol are liquids at room temperature.

Q # 5: Identify the process occurring in each of the following.

a. Mothballs slowly disappear.

Ans: Mothballs undergo a physical change called sublimation. In this change the solid goes directly into the vapour state without melting.

b. A cold windshield becomes stuck with ice when stuck by raindrops.

Ans: Freezing point of water is 0°C. If the temperature of windshield is below 0oC, rain drops stuck windshield and change into ice.

Q # 6: An autoclave is used to sterilize surgical equipment. It is far more effective to protect steam by autoclave than steam produced from boiling water in the open atmosphere, because it generates steam at a pressure of two atmospheres. Explain why an autoclave is such an efficient sterilization device.

Q # 7: The following table shows the melting points and boiling points of four substances.

Substance	Melting point (°C)	Boiling point (°C)
A	-123	-79
B	-17	58
C	52	305
D	-6	120

a. What is the physical state of each substance at room temperature and 1 atm?

Ans:

A: Gas B: Liquid C: Solid D: Liquid

b. Which substance exists as a liquid for a longest range of range of temperatures?

Ans: C

c. Describe what will happen to the substance B when it is heated from 0°C to 100°C.

Ans: Substance B is a liquid at 0oC. When we heat it from 0°C to 100°C, it converts into gas because its boiling point is 58°C.

d. Describe what will happen to the substance D when it is cooled from 100°C to -10°C. Ans: Substance D is a liquid at 100°C. When it is cooled from 100°C to -10°C, it is converted into solid because its freezing point is -6 °C.

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CHAPTER – 6 SOLUTIONS

Self assessment 6.1

The maximum amount of sodium acetate that dissolves 100g of water at 0c is 119g and 170g at 100c

(a) If you add 170g of sodium acetate in 100g of water at 0^0C, how much will dissolve?

= 119g.

(b) Is the solution saturated unsaturated or supersaturated?

= saturated.

(c) If the solution is heated to 100^0C, is the solution now saturated, unsaturated and supersaturated?

=supersaturated.

(d)If the solution is cooled back to 0c and no crystal appear -is solution is?

=supersaturated.

Self assessment 6.2

Identify the type of solution

a. Deep sea drives use breathing mix of Helium and Oxygen?

Gas in Gas

b. Brass contain 80% copper and 20% zinc?

Solid in Solid

c. Dental filling?

Liquid in solid

d. Brine (Salt in water)?

Solid in liquid

e. Drinking water containing chlorine as disinfectant.

Gas in liquid

f. Gemstone -Ruby contain Cr2 O3 and Al2 O3?

Solid in solid

g. conc.H2 SO4 we use in the laboratory is 98% H2 SO4 and contains only 2% H2O.

Liquid in liquid

Self assessment exercise 6.3

Q.No.1: Write four ways to express percentage of solutions.

1: Mass by mass (m/m).

It is the mass of the solute dissolved per 100 parts by mass of solution.

2: Mass by volume (m/v)

It is the mass of the solute dissolved per 100 parts by volume of solution

3: Volume by mass (v/m).

It is the volume of the solute dissolved per 100 parts by mass of solution

4: Volume by volume (v/v).

It is the volume of the solute dissolved per 100 parts by volume of solution

Q.No.2: A saline solution is administered intravenously to a person suffering from severe dehydration .This is labeled as 0.85% m/v of NaCl. What does it mean?

Answer: If you dissolve 0.85g NaCl in sufficient water to make 100cm^3 solution, the resulting solution will be 0.85%m/v.

Self assessment exercise 6:4

Potassium chlorate is a white solid. It is used in making matches and dyes. Calculate the Molarity of solution that contain.

(a) 1.5 moles of this compound dissolved to produce 250cm^3 of solution.

Volume of solution in dm^3	**= 250/1000 dm^3**
	= 0.25 dm^3
No. of moles	**= 1.5 moles**
Molarity=?	
Molarity	**= No. of moles/volume of solution in dm^3**
Molarity	**= 1.5mol/0.25dm^3**
Molarity	**= 6 M**

(b) 75g of this compound dissolved to produce 1.25 dm^{3}of solutions.

Mass of solute KClo$_3$	**= 75 g**
Molar mass of solute KClo$_3$	**= 39+35.5+48**
	= 122.5 g/mol
Volume of solution	**=1.25dm^3**
Molarity=?	

Molar mass =39+35.5+16*3

=122.5g/mol

No. Of moles=mass in gram/molar mass

=75g/122.5g/mol

=0.612mol.

Molarity = No. Of moles of solute/ dm^3 of solution

=0.612mol/1.25 dm^3

0.489M

(C) What is the Molarity of a 50 cm^3 sample of potassium chlorate solution that yields 0.25 g residue after evaporation of the water?

Mass of solute $KClo_3$ = 0.25 g

Molar mass of solute $Kclo_3$ = 39+35.5+48

= 122.5 g

Volume of solution = $\frac{50 \ cm^3}{1000}$ = 0.05 dm^3

Molarity =?

Molar mass=39+35.5+16*3

=122.5g/mol

No. Of moles=mass in gram/molar mass

=0.25g/122.5g/mol

=0.00204mol.

Molarity = No. Of moles of solute/ dm^3 of solution

=0.00204mol /0.05 dm^3

0.0408M

Self assessment exercise 6.5

1. NaOH solutions are used to neutralize acids and in the preparations of soaps and rayon.
   If you dissolve 25g of NaOH to make 1dm^3 of solution, what is the Molarity of solution?
   Solution:
   Mass in g =25g
   Volume = V =1 dm^3
   Molarity =M=?
   Molar mass of NaOH =23+16+1.008
   =40g/mol
   No. of moles=Mass in g/Molar mass
   =25g/40g/mol
   No. of moles=0.624mol
   Molarity= No. of moles/ dm^3 of solution

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$$=0.624mol/1dm^3$$
$$\text{Molarity}=0.624M \text{ Answer}$$

2. **A solution of NaOH of concentration 1.2M. Calculate its mass in g/dm^3 in this solution.**
   Solution:
   Molarity = 1.2M
   Mass =?
   Volume =1 dm^3
   Molar mass of NaOH =23+16+1.008
   $$=40.008g/mol$$
   Molarity= no. of moles/dm^3 of solution
   No. of moles=Molarity × dm^3 of solution
   $$=1.2mol/ dm^3 \times 1dm^3$$
   No. of moles=1.2 moles
   No. of moles=Mass in g/ Molar mass
   Mass in g=No. of moles ×Molar mass
   $$=1.2 \text{ moles} \times 40.008g/mol$$
   Mass = 48g Answer

3. **A solution is prepared by 10g of hemoglobin in enough water to make up 1 dm^3 in volume. Calculate its Molarity. Molar mass of hemoglobin is 6.51 × 10^4 g/mol.**

   Solution:

   Mass in g =10g

   Molar mass of hemoglobin=6.51 × 10^{4}g/mol

   No. of moles =Mass in g/Molar mass

   $$=10g/6.51 \times 10^4g/mol$$

   No. of moles=1.53 × 10^{4}moles

   Molarity= No. of moles/ dm^3 of solution

   $$=1.53 \times 10^{-4}mol/1dm^3$$

   Molarity= 1.53 × 10^{-4}M Answer

   Self assessment exercise 6.6

1. **How can you prepare 500cm^3 of 0.2M KMnO$_4$ solution?**
   Solution:
   Molarity = 0.2mol/ dm^3
   Volume = V = 500cm^3/1000
   $$=0.5 dm^3$$
   Molarity= No. of moles/ dm^3 of solution

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No. of moles = Molarity × dm^3 of solution

$$=0.2mol/dm^3 × 0.5 dm^3$$

No. of moles= 0.1 moles

Molar mass of KMnO$_4$=39+55+64

$$=158g/mol$$

No. of moles =Mass in g/Molar mass

Mass in g = No. of moles × Molar mass

0.1mol × 158g/mol

Mass in g = 15.8g Answer

So, we will dissolve 15.8 of KMnO$_4$ in 0.5 dm^3 to get the solution.

2.   **How can you prepare 25cm^3 of 0.25M solution of CuSO$_4$.5H$_2$O**

   <u>Solution:</u>

   Molarity = 0.25M

   Volume = 25cm^3/1000

   $$=0.025 dm^3$$

   Molarity = No. of moles/ dm^3 of solution

   No. of moles = Molarity × dm^3 of solution

   $$=0.25mol/dm^3 × 0.025 dm^3$$

   No. of moles = 6.25 × 10^{-2}moles

   Molar mass of CuSO$_4$.5H$_2$O =63.5+32+ [16×4] +5[18]

   $$=63.5+32+64+90$$

   $$=249.5g/mol$$

   No. of moles = Mass in g/Molar mass

   Mass in g = No. of moles × Molar mass

   = 6.25 × 10^{-2}mol × 249.5g/mol

   Mass = 1.559g Answer

   So, we will dissolve 1.559g of CuSO$_4$.5H$_2$O in 0.025dm^3 to get solution.

Self assessment exercise 6.7

1.   **A stock solution of HCl is 12.1M. How many cm^3 of this solution should you use to prepare 500cm^3 of 0.1M HCl?**

   <u>Solution:</u>

   M_1 = 12.1M

   V_1 =?

   M_2 = 0.1M

   V_2 = 500 cm^3

   $M_1V_1 = M_2V_2$

   12.1M ×V_1 = 0.1M ×500 cm^3

   V_1 = 50M cm^3/12.1M

   V_1 = 4.13 cm^3 Answer

2.   **K$_2$Cr$_2$O$_7$ is a red-orange compound, is a strong oxidizing agent and used in the estimation of iron content in ores. A stock solution is 2.5M K$_2$Cr$_2$O$_7$. How many cm^3 of this solution you need to make dilute to make 50 cm^3 of 0.05M K$_2$Cr$_2$O$_7$?**

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Solution:

$M_1 = 2.5M$

$V_1 = ?$

$M_2 = 0.05M$

$V_2 = 50 \text{ cm}^3$

$M_1V_1 = M_2V_2$

$2.5M \times V_1 = 0.05M \times 50 \text{ cm}^3$

$V_1 = 0.05M \times 50 \text{ cm}^3/2.5M$

$\quad = 2.5M \text{ cm}^3/2.5M$

$V_1 = 1 \text{ cm}^3$ Answer.

3. *Commercial acetic acid [CH_3COOH] is 17.8 molar. How can you convert into 0.1M acetic acid?*

Solution:

$M_1 = 17.8M$

$V_1 = ?$

$M_2 = 0.1M$

$V_2 = 100 \text{ cm}^3$

$M_1V_1 = M_2V_2$

$17.8 \times V_1 = 0.1 \text{ M} \times 100 \text{ cm}^3$

$\quad\quad = 0.1M \times 100 \text{ cm}^3/17.8M$

$V_1 = 0.561 \text{ cm}^3$ Answer

Self Assessment 6.8

Q1-Sodium chloride and glucose both are soluble in water. But the solubility of NaCl is greater than glucose .Explain why?

A-Sodium chloride is an ionic compound. The negative end of water molecules is attracted to sodium ions and the positive end of water molecules is attracted to chlorine ions. These attractive forces are strong enough to overcome the strong attractions that exist between ions in NaCl. Thus sodium chloride dissolves readily while glucose is a covalent compound by combination of much hydroxyl group glucose become polar. And ionic interactions are stronger than covalent compound.

Q2-In which liquid of each of the following pairs you would KCl an ionic solid to be more soluble?

A-H20 and CCl4.

a. H_2O because it has hydroxyl group and polar .

b. CH_3OH or benzene.

CH_3OH, because it contains hydroxyl group and it is polar.

Q3.which of the following pairs of liquids is miscible?

a. Water and benzene..

A-.immiscible, because water is polar solvent and benzene is non polar.

B.benzene and CCl4...

A. miscible, because they both are non polar solvents.

C. An oil and benzene...

A- Miscible, because they both are non polar solvents.

Self Assessment 6.9

Q1-.What temperature the solubility of KNO3 and KBr is same?

A-.At 55^0C KNO_3 and KBr's solubility is same.

Q2.what is solubility of KBr at 45^0C?

A-At 45^0C the solubility of KBr is 80g/100g.means 80g of KBr dissolve in 100g of H_2O(water) or solution.

Q3.which is the greater at 40^0C, the solubility of $NaNO_3$ or solubility of KBr?

A-At 40^0C $NaNO_3$ has greater solubility than KBr.

Q- Identify from the graph the compound whose solubility is little affected with increase in temperature?

A-NaCl is a compound who solubility is little affected with increase in temperature.

REVIEW QUESTIONS

Q1: Encircle the correct answers

1: The maximum amount of sodium acetate that dissolves in 100g of water at 0'C is 119 g and 170g at 100'C. If you place 170g of sodium acetate in 100g of water at 0'C, the resulting solution would be.

    A. Unsaturated
    B. <u>Saturated</u>
    C. Supersaturated
    D. 1M

2: How many moles of Sodium atoms are present in 2.3g of Na?

    A. 1
    B. 1.5
    C. <u>0.1</u>
    D. 0.15

3: What is the mass of 5 moles of hydrogen gas?

    A. 5g
    B. 5.04g
    C. <u>10.08g</u>
    D. 1.008g

4: How many atoms are there in 28g of nitrogen gas?

A. 2
B. 1
C. <u>6.022 X 10(23)</u>
D. 12.044 X 10(21)

5: How many atoms are there in 0.1 mole of carbon?

A. 6.022 X 10(23)
B. <u>6.022 X 10(22)</u>
C. 6.022 X 10(24)
D. 6.022 X 10(21)

6: A solution of NaOH has a concentration of 4 g/dm(cube). What is the mass of NaOH contained in 250 cm(cube) of this solution?

A. 40g
B. 20g
C. <u>1g</u>
D. 2g

7: Which of the solution is more dilute?

A. 1M
B. 2M
C. 0.1M
D. <u>0.009M</u>

8: A solution of NaOH contains 20g of this compound in 2dm(cube) of solution. What is the molarity of this solution?

A. 2M
B. 1M
C. <u>0.25M</u>
D. 0.5M

9: Which quantity is same for one mole of hydrogen gas and one mole of water?

A. Mass
B. Number of atoms
C. <u>Number of molecules</u>
D. Number of gram atomic mass

10: If one mole of Na contains x atoms of sodium, what is the number of moles contained in 46g of sodium?

A. X
B. 2
C. <u>2x</u>
D. 1.5x

Q.2:   Give short answers.

1- Differentiate between saturated and unsaturated solution?

Ans: <u>**Saturated Solution:**</u>

The solution which cannot dissolve more solute at a particular temperature is called a saturated solution.

<u>**Unsaturated Solution:**</u>

A solution which can dissolve more of the solute at a given temperature is called an unsaturated solution.

2- Give example of a solid solution containing two solids.

Ans: <u>**Brass:**</u>

Brass is an alloy of copper and zinc

<u>**Steel:**</u>

Steel is an alloy of iron containing small amounts of carbon and silicon. Many naturally occurring gemstones are called solutions. For example: Ruby, Opal etc. In these solutions a solid solute dissolves in a solid solvent. We call these solutions as solids in solids.

3- Can you call collide a solution?

Ans: Yes, collides are heterogeneous solutions.

<u>**Examples:**</u>
  I.   **Starch solution**
 II.   **White of an egg**
III.   **Gelatin, glue, gums, Milk, rubber, fog, dust in the air, jellies, paints, blood and starch in water.**

4- Gasoline does not dissolve in water. Why?

Ans: Gasoline and oils do not dissolve in water. Look into the nature of gasoline and oil molecules. Gasoline and oil molecules are non-polar in nature, the attraction between a water molecule and oil or gasoline molecule is very weak, so these liquids are insoluble in water.

5- Are gem stones solutions?

Ans: Yes, many naturally occurring gemstones are solid solutions. For example Ruby, Opal, etc. In these solutions a solid solute dissolves in a solid solvent. We call these solutions as solids in solids.

Q3: A tiny crystal of a solid substance is added to an aqueous solution of the same substance. What would happen if the original solution was?

(1) <u>Supersaturated</u>:

<u>Ans:</u> Full solution will turn into crystal form.

(2) <u>Unsaturated</u>:
<u>ANS:</u> It would dissolve in that solution.
(3) <u>Saturated</u>:
<u>ANS:</u> It will settle down at the bottom.

Q#4) Explain why CH_3OH is soluble in water but C_6H_6 is not?
Ans: Because CH_3OH is alcohol and it,s molecule are polar but C_6H_6 benzene , it is non-polar that is why CH_3OH is soluble in water and C_6H_6 is not soluble in water
Q#5) How can you prepare 250cm3 of 0.5M $MgSO_4$ from a stock solution of 2.5M $MgSO_4$?
Ans: M1V1=M2V2
M1= 2.5M
V1=?
M2= 0.5M
V2= 250cm3
2.5M x V1= 0.5M x 250cm3
V1= <u>0.5M x 250cm3</u>
         2.5M
V1= 50cm3

Q6: Complete the following table for aqueous solution of NaOH?
ANS:

MASS OF SOLUTE	MOLES OF SOLUTE	VOLUME OF SOLUTION	MOLARITY
20g	0.5 moles	0.5 dm3	1M
10g	0.25moles	1 dm3	0.25M
0.8g	0.02 moles	0.2 dm3	0.1M

7. Give examples of the following solutions:

a. **A liquid solution of a liquid solvent and gaseous solution**
b. **A solid solution of two solids**

a. **Tap water, soda water, carbonated drink, ocean water etc.**
b. **Brass:**

   Brass is an alloy of copper and zinc.

Steel:

   Steel is an alloy of iron containing small amounts of carbon and silicon. Many naturally occurring gemstones are solid solutions. For example Ruby, Opal in these solutions a solid solute dissolves in a solid solvent. We call these solutions as solid in solids.

8. What is the molarity of a solution prepared by dissolving 1.25 g of HCL gas into enough water to make 30 cm^3 of solution? *Solution:*

ANSWER: Mass (in grams) = 1.25g

Volume=30cm^3/1000

=0.03dm^3

Molar mass of HCl= 1+35.5

=36.5gmol^{-1}

Number of moles= mass (in grams)/molar mass

= 1.25g/36.5gmol^{-1}

=0.034moles

Molarity= number of moles/dm^3 of solution

=0.034 moles/0.03 dm^3

=1.142M

9. Formalin is an aqueous solution of formaldehyde (HCHO), used as a preservative for biological specimens. A biologist wants to prepare 1 dm^3 of 11.5 M formalin. What mass of formaldehyde he requires?

Solution:

ANSWER: Volume = 1dm^3

Molarity= 11.5M

Molarity= number of moles/dm^3 of solution

Number of moles=molarity x dm^3 of solution

=11.5M x 1dm^3

=11.5 moles

Molar mass of HCHO=1.008+12+1.008+16

=30.016M

Number of moles= mass(in grams)/molar mass

Mass(in grams)=number of moles x molar mass

=11.5 moles x 30.016M

=345.184g

10. A solution of Ca(OH)$_2$ is prepared by dissolving 5.2 mg of Ca(OH)$_2$ to a total volume of 1000 cm^3. Calculate the molarity of this solution.

Solution:

:   Mass=5.2mg

=5.2/1000
=0.052g
Volume=1000cm^3
=1000/1000
=1dm^3
Molar mass of $Ca(OH)_2$= 40+(17)2=74 g/mol

Number of moles= mass(in grams)/molar mass
=0.052g/74g/mol
=7.027 x 10^{-4} moles
Molarity=number of moles/dm^3 of solution
=7.027 x 10^{-4}/ 1dm^3
=7.027 x 10^{-4} M

Q No11: Calculate the number of moles of solute present in 1.25 cm^3 of 0.5M H_3PO_4 solution.

Ans: Sol:

ANSWER: Volume= 1.25cm^3

=1.25/1000

=0.00125dm^3

Molarity=0.5M

Molar mass of H_3PO_4=3+31+4x16

=98 g/mol

Molarity= number of moles/dm^3 of solution

Number of moles=molarity x dm^3 of solution

=0.5M x 0.00125dm^3

=0.000625moles

Q No12: Calculate the new molarity when 100 cm^3 of water is added to 100cm^3 of 0.5M HCL

Ans: M_1 =?

M_2 =0.5M

V_1 =100cm^3

V_2 = 100+100 = 200cm^3

M_1V_1=M_2V_2
M_1 x 100cm^3 = 0.5M x 200cm^3

M_1 = 0.5M x 200cm^3 / 100cm^3

M_1 = 0.25M.

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Question # 13

How are solutions useful for society? Give three examples.

Answer:

1: We encounter many substances in our daily life such as air, soft drinks, juices, shampoo, petrol, natural gas, diesel, kerosene, cough, syrup and many other substances are solutions.

2: Most of the chemical reactions that take place in the bodies of living organisms occur in aqueous solutions.

3: Brass, steel, German silver are also solutions. These solutions are widely used for making cooking utensils tools, cutlery, musical instruments and many other objects.

Think – Tank

Q no1:   A 10g of solid is placed in 100g of water at 20°C and all of its dissolves. Then another 4g of the solute is added at 20°C and all of its dissolves.

(a): Is the first solution saturated, unsaturated or supersaturated?

Ans: The first solution is unsaturated because its dissolves the given amount of solid at given temperature.

(b): Is it possible to tell from this information that the final solution is unsaturated or saturated?

Ans: No! The information given is not sufficient to answer whether the final solution is saturated or unsaturated.

Question # 2 What should you do to change?

    (a)   **A saturated solution to an unsaturated solution.**
    (b)   **An unsaturated solution to a saturated solution.**

Answer:

    (a)   **1. Add more solvent.**
           2. Increase temperature.

(b) **Evaporate some solvent if solute is non-volatile OR increase temperature or Keep adding solute until the solvent cannot any more at given temperature.**

Question # 3

Knowing the Molartiy of a solution is more meaningful than knowing whether a solution is dilute or concentrated. Explain.

Answer: Knowing the Molartiy is more meaningful because by knowing it you can not only know if it is diluted or concentrated, but also the actual concentration.

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Dilute/Concentrated	Molarity
➢ **Definition The solution which has lesser or greater amount of solute is called dilute or concentrated.** ➢ **It is a qualitative property.** ➢ **It never gives information about actual amount of solute.** ➢ **It is less accurate and reliable.**	➢ **Number of moles of solute present in dm³ of solution.** ➢ **It is a quantitative property.** ➢ **It gives the values in terms of number, actual amount of solute present in solution.** ➢ **It is more reliable and accurate**

Question # 4

Design an experiment to determine the solubility of table sugar in water at room temperature.

Answer:

Prepare saturated solution of sugar in 100g water. Take this solution in a pre-weighed china dish. Place china dish on the burner and heat it slowly till water evaporates completely. Cool china dish and weigh it. Calculate the mass of sugar present in it. Solubility of sugar in 100 g water room temperature is 204 g.

Temperature	0	20	40	60	80	100
NaCl	**35.5**	**36**	**36.5**	**37.5**	**38**	**39**
Sucrose (Sugar $C_{12}H_{22}O_{11}$)	**179**	**204**	**241**	**288**	**363**	**487**

Question # 5

Design an experiment to prepare 10% mass by volume solution of $CuSO^4.5H_2O$ (Nelathota).

Answer: 10%m/v concentration:

If we dissolve 10g $CuSO_4.5H_2O$ (Nelathota) in sufficient water to make 100 cm3 solutions, the resulting solution will be 10% m/v.

Question # 6

Which solution is more dilute 50 cm³ of 0.2M NaOH or 100 cm³ of 0.1M NaOH.

Solution: Case 1:

Volume of solution in dm³ = 50 dm³/1000 = 0.05 dm³

Molarity (M) = 0.2 M

Number of moles =?

Molarity (M) = Number of moles/Volume of solution in dm³

** 0.2=Number of moles/0.05**

Number of moles = 0.2*0.05 = 0.01 moles

Case 2:

Volume of solution in dm^3= 100 dm^3/1000 = 0.1 dm^3

Molarity (M) = 0.1M

Number of moles =?

Molarity (M) = Number of moles/volume of solution in dm^3

⇨ **0.1= Number of moles/0.1**
Number of moles = 0.1*0.1 = 0.01 moles.

Question no 7

Which solution is more concentrated 100 cm^3 of 0.1 MHCL or 100 cm^3 of 0.1M NaOH.

Ans:- 0.1M HCL of 100 cm^3

MOLARITY = No of moles/ dm^3 of solution

Volume of HCL = 100 cm^3/1000

= 0.1 dm^3

Molarity = 0.1M

0.1mol/dm = No of moles

0.1 dm^3

No. of moles = 0.1 mol x 0.1 = 0.01 mol

Molar mass of HCl=1.008+35.5

=36.5g/mol

Number of moles= mass (in grams)/molar mass

Mass (in grams) =number of moles x molar mass

=0.01 moles x 36.5g/mol

=0.365g

0.1M NaOH of 100 cm^3

MOLARITY = No of moles/ dm^3 of solution

Volume of HCL = 100 cm^3/1000

= 0.1 dm^3

Molarity = 0.1M

0.1mol/dm^3 = No. of moles

0.1 dm^3

No. of moles = 0.1 mol x 0.1 = 0.01 mol

Molar mass of NaOH =23+16+1.008

$$=40g/mol$$

Number of moles= mass (in grams)/molar mass

Mass (in grams) =number of moles x molar mass

$$=0.01 \text{ moles x } 40g/mol$$

$$=0.4g$$

Question no: 8

Brenzene is a common organic solvent. Its use is now restricted because this can cause cancer. The recommended limit of exposure to benzene is 0.32 mg per dm^3 of air. Calculate molarity of this solution.

ANS:- Mass in grams. = 0.32 mg

$$= \underline{0.32}$$
$$1000$$

$$= 3.2 \times 10^{-4}$$

Volume $= 1 \, dm^3$

Molarity $= ?$

Molar mass of benzene $C_6H_6 = 6(12) + 6(1.008)$

$= 32 + 6.048$

$= 78.048$ g/mol.

No. of moles = Mass in grams/Molar Mass2

$$= 3.2 \times 10^{-4g}/78.048 \text{ g/mol}$$

$$= 4.10 \times 10^{-6} \text{mol}$$

MOLARITY

Molarity=No. of moles\dm^3 of solution

$=4.10 \times 10^{-6}$mol \ 1 dm ^{3}

Molarity $= 4.10 \times 10^{-6}$mol/dm^3

OR

Molarity $= 4.10 \times 10^{-6}$M

Q No: 9

A Patient in a hospital is often administered an intravenous (IV) drip containing an aqueous solution. This aqueous solution contains 0.85% (mass by volume of sodium chloride or 5% (mass by volume) of glucose. Calculate the molarity of both these solutions.

Solution:

0.85%m/v of NaCl

Mass in grams of NaCl = 0.85g

Volume $\quad$ = $\quad$ 100 cm^3/1000

$\quad\quad$ = 0.1 dm^3

Molarity $\quad$ = ?

Molar mass of NaCl = 23+35.5

=58.5 g/mol.

No. of moles = Mass in grams/Molar Mass2

$\quad\quad$ = 0.85g/58.5 g/mol.

$\quad$ = 0.0145mol

MOLARITY

Molarity=No. of moles\dm^3 of solution

=0.0145mol \ 0.1dm^3

Molarity = 0.145mol/dm^3 $\quad$ OR $\quad$ Molarity = 0.145M

5% M/V of C$_6$H$_{12}$O$_6$

Mass in grams of C$_6$H$_{12}$O$_6$ = 5g

Volume $\quad$ = $\quad$ 100 cm^3/1000

$\quad\quad$ = 0.1 dm^3

Molarity $\quad$ = ?

Molar mass of C$_6$H$_{12}$O$_6$ = [6X12+1X12+6X16]

= [72+12+96]

= 180 g/mol.

No. of moles = Mass in grams/Molar Mass2

$\quad\quad$ = 5g/180 g/mol.

$\quad\quad$ = 0.0277mol

MOLARITY

Molarity=No. of moles\dm^3 of solution

=0.0277mol \ 0.1dm^3

Molarity = 0.277mol/dm^3 $\quad$ OR $\quad$ Molarity = 0.277M

Question 10:

100cm^3 of NaOH solution was heated to complete dryness, 1.5g residue left behind. What was the molarity of the solution.

Solution:

Mass of solute NaOH=1.5 g

Molar mass of solute NaOH=23+16+1=40g/mol

Volume of solution = 100 cm^3/1000

= 0.1 dm^3

Molarity (M) =?

No. of moles = Mass in grams/Molar Mass2

= 1.5g/40g/mol.

= 0.0375mol   MOLARITY

Molarity=No. of moles\dm^3 of solution

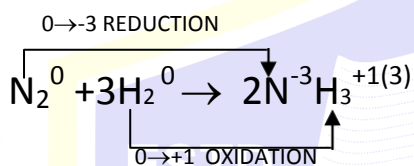**=0.0375mol \ 0.1dm^3 Molarity = 0.375mol/dm^3**
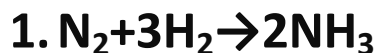
OR   Molarity = 0.375M

Chapter : 7

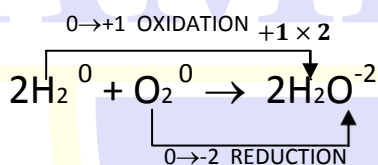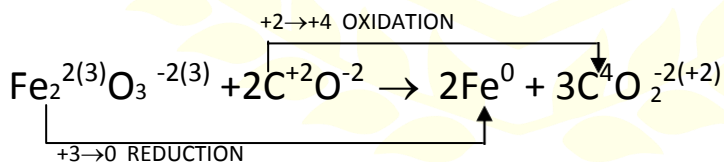# Electrochemistry

SELF ASSESSMENT 7.1

Identify elements undergo oxidation and reduction in the following.

1. $N_2 + 3H_2 \rightarrow 2NH_3$

$$N_2{}^0 + 3H_2{}^0 \rightarrow 2N^{-3}H_3{}^{+1\times3}$$

0→-3 REDUCTION

$$N_2{}^0 + 3H_2{}^0 \rightarrow 2N^{-3}H_3{}^{+1(3)}$$

0→+1 OXIDATION

- Nitrogen will undergo reduction because there is a decrease in oxidation number (0→-3).
- Hydrogen will undergo oxidation because there is an increase in oxidation number (0→+1).

2. $2H_2 + O_2 \rightarrow 2H_2O$

$$2H_2{}^0 + O_2{}^0 \rightarrow 2H_2{}^{+1\times2}O^{-2}$$

0→+1 OXIDATION $+1 \times 2$

$$2H_2{}^0 + O_2{}^0 \rightarrow 2H_2O^{-2}$$

0→-2 REDUCTION

- Hydrogen will undergo oxidation because there is increase in oxidation number (0→+1(2)).
- Oxygen will undergo reduction because there in decrease in oxidation number (0→-2).

3. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

$$Fe_2{}^{+3\times2}O_3{}^{-2\times3} + 3C^{+2}O^{-2} \rightarrow 2Fe^0 + 3C^{+4}O_2{}^{-2\times2}$$

+2→+4 OXIDATION

$$Fe_2{}^{2(3)}O_3{}^{-2(3)} + 2C^{+2}O^{-2} \rightarrow 2Fe^0 + 3C^4O_2{}^{-2(+2)}$$

+3→0 REDUCTION

Iron will undergo reduction because there is decrease in oxidation number (+3→0).

Carbon will undergo oxidation because there is increase in oxidation number (+2→+4).

4. $4Al + O_2 \rightarrow 2Al_2O_3$

$$4Al^0 + 3O_2{}^0 \rightarrow 2Al_2{}^{+3\times2}O_3{}^{-2\times3}$$

0→+3 OXIDATION

$$Al^0 + 3O_2{}^0 \rightarrow 2Al_2{}^{2(+3)}O_3{}^{3(-2)}$$

0→-2 REDUCTION

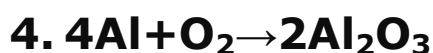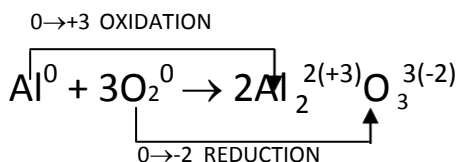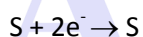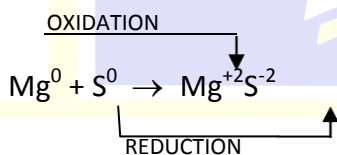Aluminum will undergo oxidation because there is increase in oxidation number (0→+3(2)).

Oxygen will undergo reduction because there is decrease in oxidation number (0→-2(3)).

Self assessment 7.2:

In following reactions, identify which element is oxidized and which element is reduced?

1. Mg+ S→ Mg S

$$Mg^0 + S^0 \rightarrow Mg^{+2}S^{-2}$$

OXIDATION

$$Mg^0 + S^0 \rightarrow Mg^{+2}S^{-2}$$

REDUCTION

$Mg \rightarrow Mg + 2e^-$

$S + 2e^- \rightarrow S$

Magnesium will undergo oxidation because there is increase in oxidation number (0→2)

Sulfur will undergo reduction because there is decrease in oxidation number (0→-2).

2. $4Na + O_2 \rightarrow 2Na_2O$

$$4Na^0 + O_2{}^0 \rightarrow 2Na_2{}^{+1(2)}O^{-2}$$

OXIDATION

$$4Na + O_2 \rightarrow 2Na_2O$$

REDUCTION

$4Na \rightarrow 4Na + 4e^-$

$O_2 + 4e^- \rightarrow O_2{}^-$
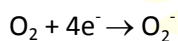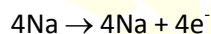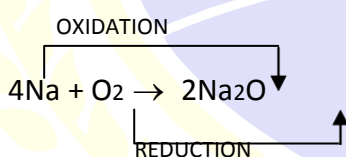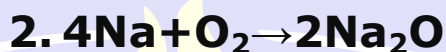
Sodium will undergo oxidation because there is increase in oxidation number (0→1)

Oxygen will undergo reduction because there is decrease in oxidation number (0→-2)

3. $2Al + 3Cl_2 \rightarrow 2AlCl_3$

$$2Al^0 + 3Cl_2{}^0 \rightarrow 2Al^{+3}Cl_3{}^{-1(3)}$$

OXIDATION

$$2Al + 3Cl_2 \rightarrow 2AlCl_3$$

REDUCTION

$$2Al \rightarrow Al^{+3} + 6e^-$$

$$3Cl_2 + 6e^- \rightarrow 6Cl$$
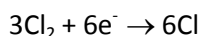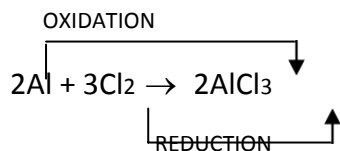
Aluminum will undergo oxidation because there is increase in oxidation number (0→+3)

Chlorine will undergo reduction because there is decrease in oxidation number (0→-1)

4. $Mg+H_2 \rightarrow MgH_2$

$$Mg^0+H_2{}^0 \rightarrow Mg^{+2}H_2{}^{-1(2)}$$

OXIDATION

$$Mg + H_2 \rightarrow MgH_2$$

REDUCTION

$$Mg \rightarrow Mg^{+2} + 2e^-$$

$$H_2 + 2e^- \rightarrow 2[H]^{-1}$$

Magnesium will undergo oxidation because there is increase in oxidation number (0→+2)

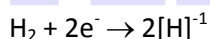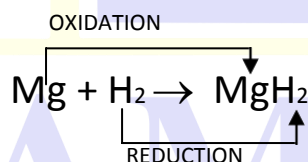Hydrogen will undergo reduction because there is decrease in oxidation number (0→-1)

Self assessment 7.3:

One major problem is the formation of acid is formation of acid rain. Air pollution such SO_2 and NO_2 combine with oxygen and water vapours in the air to from H_2SO_4 and HNO_3. These acids fall to the ground with the rain, making the rain acidic. Clouds can also absorb the acids and carry the hundred of kilometer away from where the pollutants are released.

Determine the oxidation number of N in NO_2 and HNO_3, S in SO_2 and H_2SO_4

1: Solution: Oxidation number of N in NO_2:
The sum of oxidation numbers must be zero
[O.N of N] + 2[O.N of O] = 0
[O.N of N] +2[-2] =0
[O.N of N] -4 = 0
[O.N of N] = 4
Thus oxidation state for N in NO_2 is +4

2: Solution: oxidation number of N in HNO_3
The sum of oxidation number must be zero
[O.N of H] + [O.N of N] + 3 [O.N of O] = 0
[+1] + [O.N of N] +3 [-2] = 0
[+1] + [O.N of N] -6 = 0

[O.N of N] -5 = 0
[O.N of N] = 5
Thus oxidation state for N in HNO_3 is +5

3: Solution: oxidation number of S in SO_2
The sum of oxidation must be zero
[O.N of S] + 2 [O.N of O] = 0
[O.N of S] + 2 [-2] = 0
[O.N of S] – 4 = 0
[O.N of S] = 4
Thus oxidation state for S in SO_2 is +4

4: Solution: oxidation number of S in H_2SO_4
The sum of oxidation number must be zero.
2[O.N of H] + [O.N of S] + 4 [O.N of O] = 0
2[+1] + [O.N of S] + 4 [-2] = 0
+2 + [O.N of S] -8 = 0
[O.N of S] -6 = 0
[O.N of S] = 6
Thus oxidation state for S in H_2SO_4 is +6

Self assessment 7.4:

Q:1 The torch cell discharges electricity because of an oxidation-reduction reaction that take place between zinc and manganese dioxide. Identify oxidizing and reducing agent.

$$Zn + 2 \, Mn \, O_2 + H_2O \rightarrow Zn \, (OH)_2 + Mn_2 \, O_3$$

$$Zn^0 + 2 \, Mn^{+4} \, O_2^{-2(2)} + H_2^{1(2)} \, O^{-2} \rightarrow Zn^{+2} \, (OH)_2^{-2} + Mn_2^{3(2)} \, O_3^{-2(3)}$$

0→+2 OXIDATION [REDUCING AGENT]

$$Zn^0 + 2Mn^{+4}O_2^{-2(+2)} + H_2^{+1(+2)}O^{-2} \rightarrow Zn^{+2} (OH)_2^{2(-1)} + Mn_2^{2(+3)}O_3^{3(-2)}$$

+4→+3 REDUCTION [OXIDIZING AGENT]
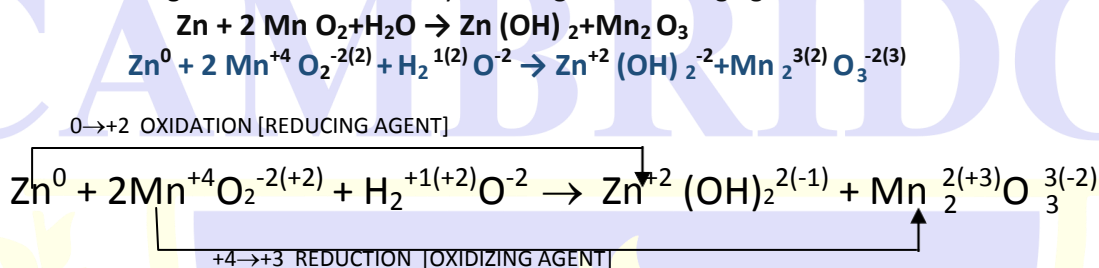
Zinc is oxidizing so it is REDUCING AGENT and Mn get reduced so it is called oxidizing agent.

. 2S+Cl$_2$ →S$_2$Cl$_2$

$$2S^0 + Cl_2^0 \rightarrow S_2^{1(2)} Cl_2^{-1(2)}$$

OXIDATION [REDUCING AGENT]

$$2S + Cl_2 \rightarrow S_2Cl_2$$

REDUCTION [OXIDIZING AGENT]
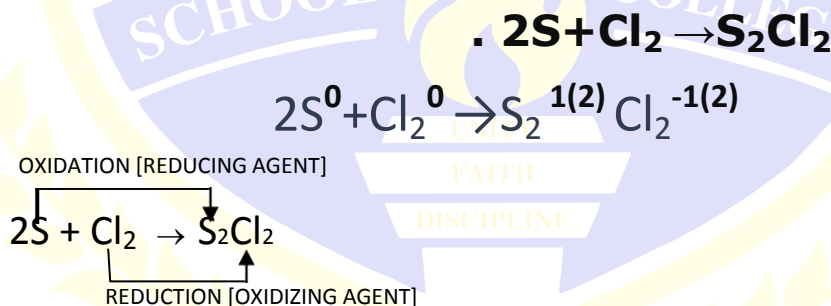
As sulfur is oxidizing so it is reducing agent.

Chlorine is reducing so it is oxidizing agent.

(a) .2Na+Br$_2$→2Na Br $2Na^0 + Br_2^0 \rightarrow 2Na^1 Br^{-1}$

OXIDATION [REDUCING AGENT]

$$2Na + Br_2 \rightarrow 2NaBr$$

REDUCTION [OXIDIZING AGENT

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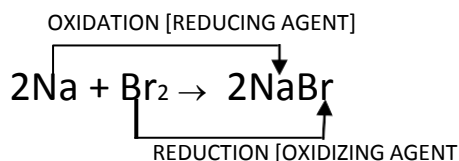
Sodium is oxidizing so it is a reducing agent. Br is reducing so it is oxidizing agent.

(b) . $H_2+S \rightarrow H_2S$ $\qquad$ $H_2^0+S^0 \rightarrow H_2^{1(2)} S^{-2}$

OXIDATION [REDUCING AGENT]

$H_2 + S \rightarrow H_2S$

REDUCTION [OXIDIZING AGENT]
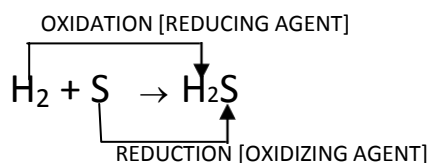
Hydrogen is oxidizing so it is a reducing agent. Sulfur reducing so it is oxidizing agent.

Self assessment 7.5:

Sketch an electrolytic cell for electrolysis of fused KCl.
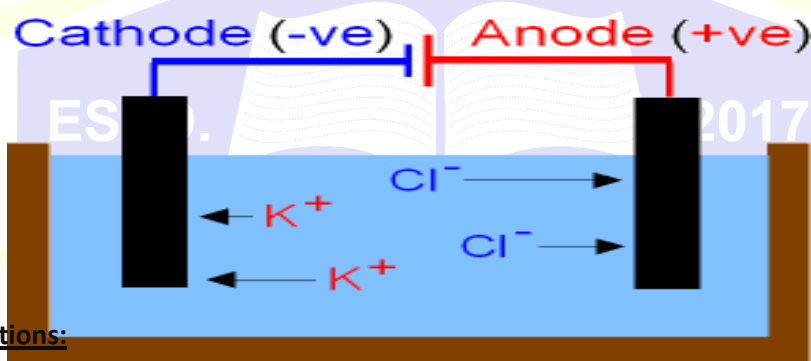
Reactions:
Anode:
$\quad$ $2 Cl^- \rightarrow Cl_2 + 2e^-$
Cathode:
$\quad$ $K^{+1} + 2e^- \rightarrow 2K$

1. Electrolytic cell is used for the electrolysis of fused sodium chloride. Indicate the direction of flow of electrons. Identify anode and cathode.
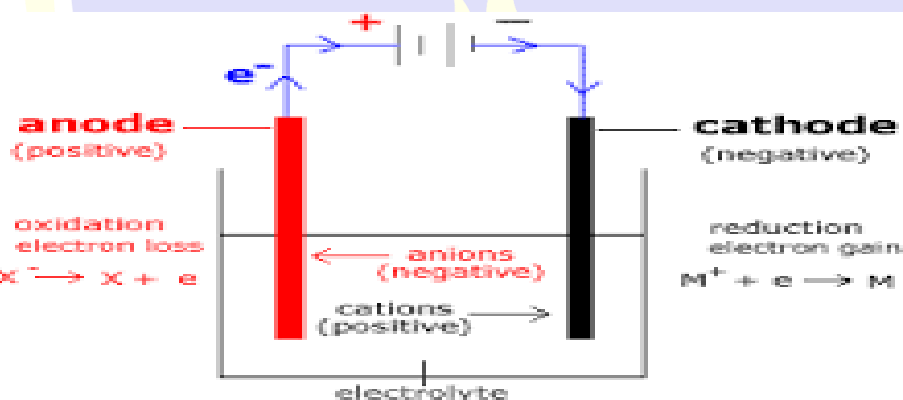
Cathode(-ve)　　　　　　　　　Anode(+ve) **Figure 1: fused NACL**

Ionization reaction:
$\quad$ NaCl $\longrightarrow$ $Na^{+1} + Cl^{-1}$
Reaction at cathode (reduction):
$\quad$ $2Na^+ + 2e^- \longrightarrow 2Na$
Reaction at anode (oxidation):
$\quad$ $2Cl^- \longrightarrow Cl_2 + 2e^-$
Net reaction:
$\quad$ $2Nacl_{(fused)} \longrightarrow 2Na + Cl_2$
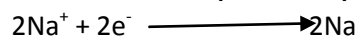
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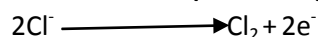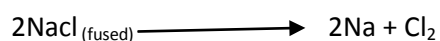
Sodium metal is collected at cathode and chlorine gas is collected at anode.

Self assessment 7.6:

Sketch a voltaic cell.

Silver, zinc, silver nitrate and zinc sulphate:

(HINT: ZNIC IS MORE ACTIVE THAN SILVER)

Graphic by Shamsher Singh
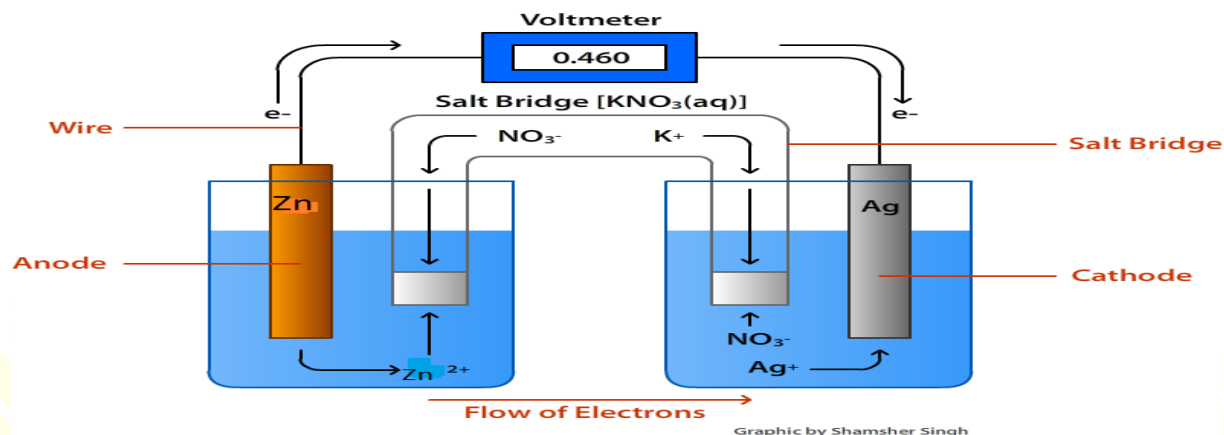
Self assessment 7.7:

Identify the half-cell in which oxidation occurs and in which reduction occur
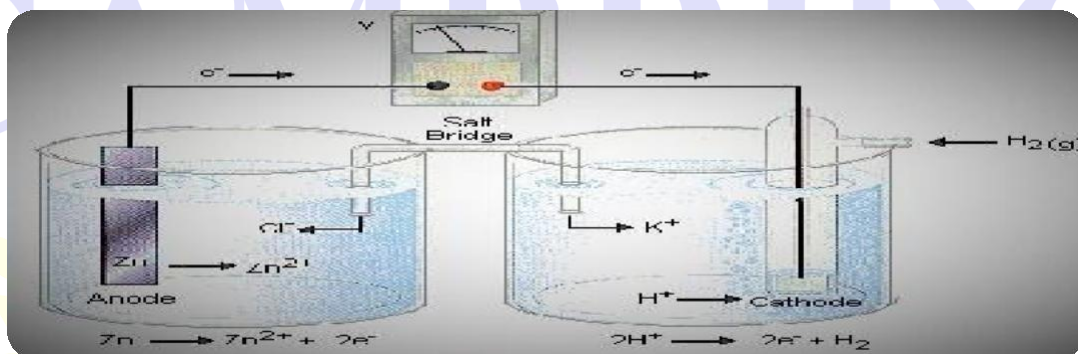
At anode (oxidation half reaction):
Zn (s) $\longrightarrow$ Zn^{+2} + 2e$^-$
At Cathode (reduction half reaction):
$H_2(g)$ + 2e$^-$ $\longrightarrow$ $2H^+$ (aq
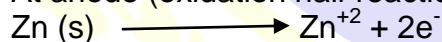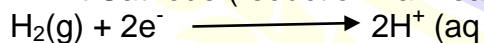
- Zn is undergoing oxidation and H_2 is undergoing reduction.

REVIEW QUESTIONS

Q#1: Encircle the correct answer:

   i.   In which of the following changes the nitrogen atom is reduced.

   A- N_2 to NO
   B- N_2 to NO_2
   C- **N_2 to NH_3**
   D- N_2 to HNO_3

ii. **Which of the following changes reaction is an example of oxidation?**

  A- Chlorine molecule to chloride ion.
  B- <u>Silver atoms to silver (I) ion.</u>
  C- Oxygen molecule to oxide ion.
  D- Iron (III) ion to iron (II) ion.

iii. **Which of the following elements in the given reaction is reduced?**

$$ZnO + H_2 \longrightarrow Zn + H_2O$$

  A- H_2
  B- ZnO
  C- <u>**Zn**</u>
  D- O

iv. **Consider the following reaction:**

$$H_2S + Cl_2 \longrightarrow 2HCL + S$$

In this reaction what does H_2S behave as?

  A- <u>**Reducing agent.**</u>
  B- Oxidizing agent.
  C- Catalyst.
  D- Electrolyte.

v. **The oxidation state of Cr in $K_2Cr_2O_7$ is**

  A- 12
  B- <u>**6**</u>
  C- 3
  D- Zero

vi. **Which of the following statement is not correct about galvanic cell?**

  A- Cations are reduced at cathode.
  B- Anions are oxidized at anode.
  C- <u>Electrons flow from cathode to anode.</u>
  D- Oxidation occurs at anode.

vii. **Which of the following is not true about the Daniel cell?**

  A- <u>**Half cell of an active metal acts as cathode.**</u>
  B- Half cell contains an element in contact with its ions in aqueous solution.
  C- A salt bridge connects the two half cells.
  D- A spontaneous oxidation-reduction reaction generates electricity.

viii. **Which of the following do not involve electrolytic process?**

  A- Refining of copper.
  B- Manufacture of sodium from NaCl.
  C- Electroplating of steel.
  D- <u>Reduction of metal oxide by a reducing agent.</u>

ix. **Galvanizing is:**

A- Coating with Sn
B- **Coating with Zn**
C- Coating with Cr
D- Coating with Cu

x. **Which of the following is true for the Nelson Cell?**

A- Sodium metal is produced at anode.
B- **Chlorine gas is produced at anode.**
C- Hydrogen gas is produced at anode.
D- Sodium ions are not reduced at cathode

Q#2: Give Short answers.

1. **What is oxidation state?**

Ans: **Oxidation states or oxidation number:**

Oxidation state or oxidation number is defined as the number of charges an atom will have in a molecule or a compound. The elements that show an increase in oxidation number are oxidized. The elements that show a decrease in oxidation number are reduced.

2. **What is the oxidation number of Cr in chromic acid (H_2CrO_4)?**

Solution: Oxidation number of Cr in Chromic acid (H_2CrO_4):
The sum of oxidation number must be zero.
2[O.N of H] + [O.N of Cr] + 4[O.N of O] = 0
2[+1] + [O.N of Cr] + 4[-2] = 0
+2 + [O.N of Cr] -8 = 0
[O.N of Cr] -6 = 0
[O.N of Cr] = +6
Thus oxidation state for Cr in H_2CrO_4 is +6

3. **Identify reducing agent in the following reaction.**

$$CuO + H_2 \longrightarrow Cu + H_2O$$

Solution:

First assign oxidation number to each atom.

$$\overset{+2\ -2}{CuO} + \overset{0}{H_2} \longrightarrow \overset{0}{Cu} + \overset{2(+1)\ -2}{H_2O}$$
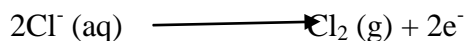
Because the oxidation number of Cu decreases (+2 to 0), So CuO is an oxidizing agent. Similarly the oxidation number of H increases (0 to +1), therefore H_2 is reducing agent.
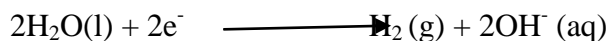
4. **Write chemical reactions that occur in Nelson's cell.**

Ans: **At anode (oxidation):**

$$2Cl^- \text{ (aq)} \longrightarrow Cl_2 \text{ (g)} + 2e^-$$

At cathode (reduction):

$$2H_2O(l) + 2e^- \longrightarrow H_2 \text{ (g)} + 2OH^- \text{ (aq)}$$

Overall Reaction:

$$2Cl^- \text{ (aq)} + 2H_2O \text{ (l)} \longrightarrow Cl_2 \text{ (g)} + H_2 \text{ (g)} + 2OH^- \text{ (aq)}$$

Note: The solution contains Na^+ and OH^- ions. Evaporation of water from this solution produces relatively pure solid sodium hydroxide. i.e.: -

$$2Na^+ \text{ (aq)} + 2OH^- \text{ (aq)} \longrightarrow 2NaOH^- \text{ (aq)}$$

5. Why tin plated steel is used to make food cans?

Ans: They are made from steel with a thin coating of tin to prevent corrosion. Tin plated steel is used to make cans. Food and beverages industries use tin plated steel cans, this is because the components of food beverages and the preservatives contain organic acids or their salts. They may form toxic substances by reacting with iron. These acids and salts are corrosive. Tin plating is non-poisonous and prevents corrosion.

6. Explain one example from daily life which involves oxidation-reduction reaction?
Following are the examples:

- Rusting involves oxidation reduction reaction.
- Photography involves oxidation reduction reaction.
- Electroplating involves oxidation reduction reaction.
- Corrosion of different metals involves oxidation reduction reaction.
- Refining involves oxidation reduction reaction.

Ans: **Redox in photography:**

A photographic film is basically an emulsion of silver bromide, (AgBr) in gelatin. When the film is exposed to light, Silver bromide granules become activated. This activation depends on the intensity of the light falling upon them. When exposed film is placed in the developer solution that is actually a reducing agent. Hydroquinone which is a mild reducing agent is used as developer. In hydroquinone the activated granules of silver bromide are reduced to black metallic silver. Reduced silver atoms form image.

$$Ag^+ + 1e^- \longrightarrow Ag \text{ (s)}$$

Inactivated silver bromide is removed from the film by using a solvent called a fixer. Sodium thiosulphate is used for this purpose. The areas of the film exposed to the light appear darkest because they have the highest concentration of metallic Silver. Thus photography involves oxidation-reduction reaction.

Q#3: Define oxidation and reduction in terms of loss or gain of oxygen or hydrogen.
Ans: Oxidation and reduction processes:

Oxidation	Reduction
Gain of oxygen	Loss of oxygen
Loss of hydrogen	Gain of hydrogen

For example:

- In steel mills iron ores, usually oxides of iron are converted to pure metal commercially by the reaction with coke in blast furnace. The carbon first reacts with air to form carbon monoxide which in turn reacts with iron oxide.

  $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO$

- Acetylene is commercially used for cutting and welding metals. When acetylene burns, it produces a very hot flame known as oxy-acetylene flame. Following reaction takes place when it burns.

  $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

- Coal is burned in thermal power stations to produce electricity. When it burns, following reaction occurs.

  $C + O_2 \rightarrow CO_2$

- **Rusting:**

  $4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Q#4: **Define oxidation and reduction in terms of loss or gain of electrons.**

Ans: Oxidation:

A process that involves the loss of electrons by an element is called oxidation.

Examples:

For example, group IA and group IIA elements lose one and two electrons respectively to form cations. In doing so, these metals undergo oxidation.

$$Na \longrightarrow Na^+ + e^-$$
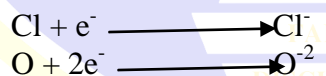$$Ca \longrightarrow Ca^{+2} + 2e^-$$

Reduction:
A process that involves the gain of electrons by a substance is called reduction.

Examples:

Elements of group VIA and VIIA gain one and two electrons respectively to form anions. They undergo reaction.

$$Cl + e^- \longrightarrow Cl^-$$
$$O + 2e^- \longrightarrow O^{-2}$$

**Q#5:** List the possible uses of electrolytic cell.

Ans: Uses of electrolytic cells:
Possible uses of electrolytic cells are as follows:

a. Down's Cell is used for the commercial preparation of sodium metal. It produces chlorine gas as by product.
b. Nelson's Cell is used for the commercial preparation of sodium hydroxide. It also produces chlorine and hydrogen as by product.

c. Electrolytic cells are used for the commercial preparation of calcium and magnesium metals.

d. It is used to produce aluminium metal commercially.

e. It is used for the purification of copper.

f. Electrolytic cells are used to electroplate metals such as tin, silver, nickel, etc.

g. Electrolytic cells are used to prepare anodized aluminum. Anodized aluminum can absorb dyes. Dyeing of anodized aluminum can produce metallic red, metallic blue or other metallic colours on the metal surface.

Q6) Sketch a daniel cell, labeling the cathode, anode, and the directtion of flow of the electrons.
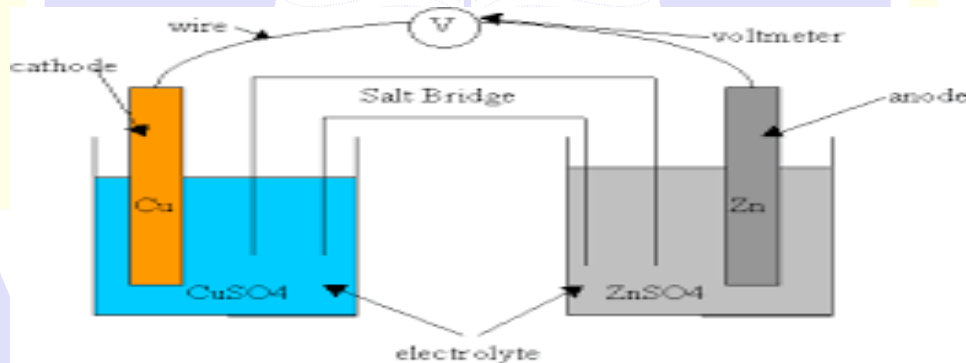
At anode $Cu^{+2} + 2e^- \rightarrow Cu$

At cathode $Zn \rightarrow Zn^{+2} + 2e^-$

Q#7: Describe how a battery produces electrical energy.

Ans: Battery (a source of electrical energy):

A battery is a galvanic cell or a group of galvanic cells joined in series. It generates electric current by a redox reaction. When connected in a circuit its anode oxidizes by releasing electrons. These electrons through the external circuit begin to flow towards the cathode. At cathode these electrons reduce oxidizing agent present in the electrolyte

**Examples:** Examples of batteries are dry cell, storage cell, mercury battery etc.

Q#8: Describe the method of recovering metal from its ores.

Ans: Method of recovering metals from their ores:

The process of producing a metal from its ores, always involve oxidation- reduction reaction. Most of the metals are found in nature as oxides or sulphide ores. After mining the ore, desired mineral is separated from the other materials. Purified metal oxides are reduced to free metals by using a reducing agent.

Use of reducing agents:

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Aluminum, coke, carbon monoxide gas and hydrogen gas are generally used as reducing agents.
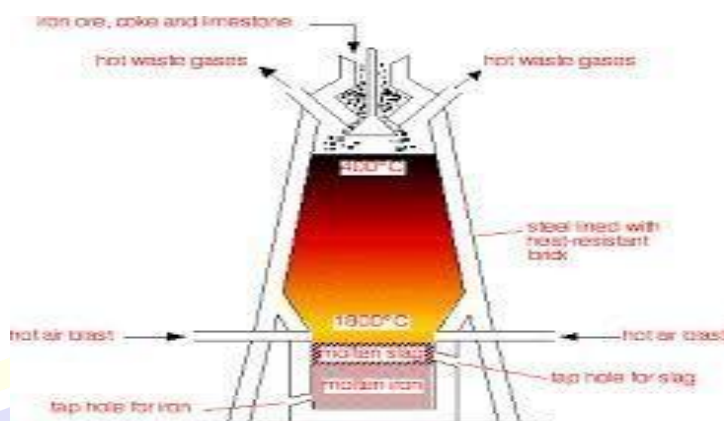
Extraction of Iron:

For example extraction of iron involves the chemical reduction of Hematite (Fe_2O_3) ore by coke (carbon) in a blast furnace.

Charge:

Iron ore, lime stone ($CaCO_3$) and coke are introduced into the blast furnace from the top. A blast of hot air is forced up the furnace from the bottom (hence the name blast furnace)

Waste gases:

The oxygen gas reacts with coke to form mostly carbon monoxide and some carbon dioxide. These reactions are highly exothermic. As hot CO rises, it reacts with iron oxide and reduces it to iron. Lime stone remove impurities from iron as slag.

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

Extraction of lead and zinc metals:

Lead and Zinc metals occur naturally as sulphide ores. These ores are first converted into corresponding oxide by heating in oxygen. In this process sulphur is oxidized and oxygen is reduced. These oxides are then reduced by coke or carbon monoxide or hydrogen.

$$ZnO + C \longrightarrow Zn + CO$$

$$PbO + CO \longrightarrow Pb + CO_2$$

$$CuO + H_2 \longrightarrow Cu + H_2O$$
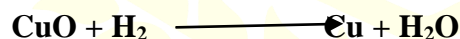
Q#9: Explain electrolytic refining of copper.

Ans: Electrolytic refining of copper:

The copper metal obtained from its ores is usually impure. It contains impurities such as zinc, iron, silver, and gold. These impurities are removed by the process of electrolysis.

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In this process impure copper bars act as anode and pure copper bars as cathode. $CuSO_4$ solution containing little sulphuric acid is used as the electrolyte.

Experimental set up for the electrolytic refining of copper.
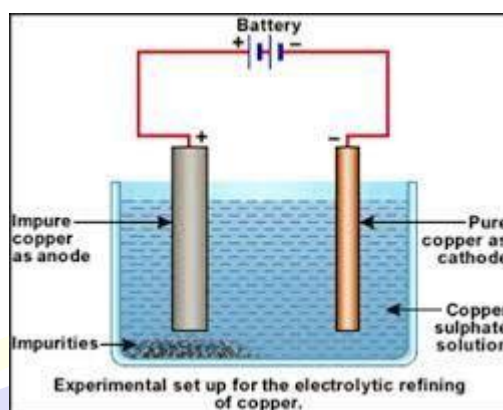
Working:

On passing electricity, copper anode dissolves forming Cu^{+2} ions. Cations move towards the cathode at which only Cu^{+2} ions are reduced. Thus pure copper deposits at cathode. The less electropositive metals, silver and gold fall to the bottom of the cell. Copper obtained in this process is 99.5% pure. Following reaction occur in this process.

At anode:

$$Cu \ (s) \longrightarrow Cu^{+2} \ (aq) + 2e^-$$

At Cathode:

$$Cu^{+2} \ (aq) + 2e^- \longrightarrow Cu \ (s)$$

Q#11: Explain how food and beverages industries deal with corrosion.

Ans: Tin plated steel is used to make cans. Food and beverages industries use tin plated steel cans, this is because the components of food beverages and the preservatives contain organic acids or their salts. They may form toxic substances by reacting with iron. These acids and salts are corrosive. Tin plating is non-poisonous and prevents corrosion.

Q#12: Explain how chemistry interacts with photography.
**Ans: interaction of chemistry with photography:**

A photographic film is basically an emulsion of silver bromide, (AgBr) in gelatin. When the film is exposed to light, Silver bromide granules become activated. This activation depends on the intensity of the light falling upon them. When exposed film is placed in the developer solution that is actually a reducing agent. Hydroquinone which is a mild reducing agent is used as developer. In hydroquinone the activated granules of silver bromide are reduced to black metallic silver. Reduced silver atoms form image.

$$Ag^+ + 1e^- \longrightarrow Ag \ (s)$$

Inactivated silver bromide is removed from the film by using a solvent called a fixer. Sodium thiosulphate is used for this purpose. The areas of the film exposed to the light appear darkest because they have the highest concentration of metallic Silver. Thus photography involves oxidation-reduction reaction.

Q#13 Electrolysis has a major role in electrochemical industries.

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a) Sketch an electrolytic cell, label the anode and cathode and indicate the direction of electron transfer.
b) Describe the nature of electrochemical process.
c) Distinguish between electrolytic voltaic. Cell.

A)
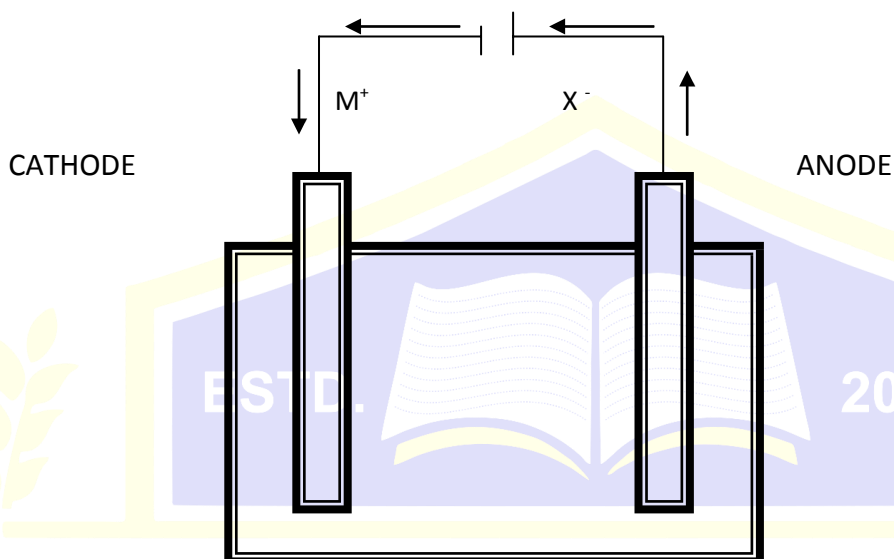
B) <u>Nature of electrochemical process:</u> Electrochemical processes are oxidation- reduction reactions in which chemical energy released by a spontaneous reaction is converted to electricity or in which electrical energy is used to drive a non-spontaneous reaction. Whether an electrochemical process releases or requires energy, it always involves the transfer of electrons from one substance to another. This means that this process always involves an oxidation-reduction reaction.

C) <u>Electrolytic cell:</u>
→ in this cell, th electrical energy is converted into chemical energy.
→in this cell, current is used to drive a chemical reaction.
→ Non-spontaneous oxidation-reduction reactions take place.
→ Electrolysis takes place in this cell.
→example:
　　　　Down cell, Nelson cell
<u>Galanic cell:</u>
→ in this cell, chemical energy is converted into electrical energy.
→ in this cell, current is produced as a result of chemical reaction.
→ Spontaneous oxidation-reduction reactions take place.
→ Electric conduction takes place in this cell.
→example:
　　　　Daniel cell, Fuel cell.

Q#14 State the substances which are oxidized or reduced. Give reason for your answer.

A) $N_2 + 3H_2 \rightarrow NH_3$

$$0 \rightarrow -3 \text{ REDUCTION}$$

$$N_2^0 + 3H_2^O \rightarrow N^{-3}H_3^{+1(3)}$$
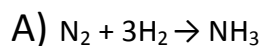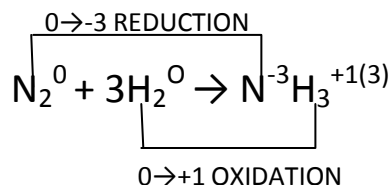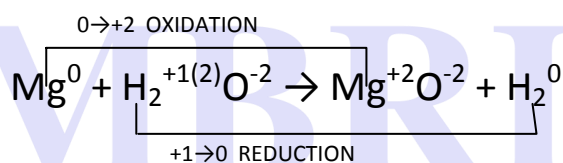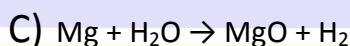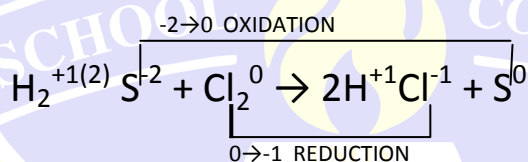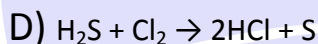
$$0 \rightarrow +1 \text{ OXIDATION}$$

Nitrogen will reduce because oxidation number is decreased from 0 to -3 and Hydrogen will oxidize because oxidation number is increased from 0 to +1.
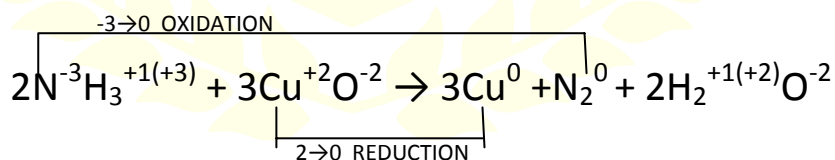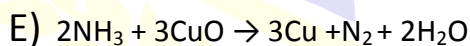
B) $CO_2 + 2Mg \rightarrow 2MgO + C$

$$+4 \rightarrow 0 \text{ REDUCTION}$$

$$C^{+4}O_2^{-2(2)} + 2Mg^0 \rightarrow 2Mg^{+2}O^{-2} + C^0$$
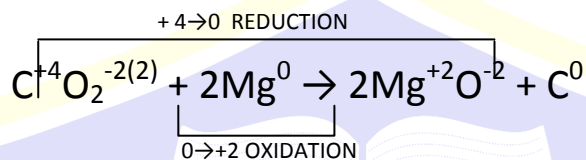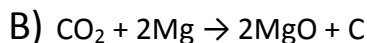
$$0 \rightarrow +2 \text{ OXIDATION}$$

C will reduce because oxidation number is decreased from +4 to 0 and Mg will oxidize because oxidation number is increased from 0 to +2.

C) $Mg + H_2O \rightarrow MgO + H_2$

$$0 \rightarrow +2 \text{ OXIDATION}$$

$$Mg^0 + H_2^{+1(2)}O^{-2} \rightarrow Mg^{+2}O^{-2} + H_2^0$$

$$+1 \rightarrow 0 \text{ REDUCTION}$$

Mg will oxidize because oxidation number is increased from 0 to +2 and **H** will reduce because oxidation number is decreased from +1 to 0.

D) $H_2S + Cl_2 \rightarrow 2HCl + S$

$$-2 \rightarrow 0 \text{ OXIDATION}$$

$$H_2^{+1(2)}S^{-2} + Cl_2^0 \rightarrow 2H^{+1}Cl^{-1} + S^0$$

$$0 \rightarrow -1 \text{ REDUCTION}$$

Cl will reduce because oxidation number is decreased from 0 to -1 and S will oxidize because oxidation number is increased from -2 to 0.

E) $2NH_3 + 3CuO \rightarrow 3Cu + N_2 + 2H_2O$

$$-3 \rightarrow 0 \text{ OXIDATION}$$

$$2N^{-3}H_3^{+1(+3)} + 3Cu^{+2}O^{-2} \rightarrow 3Cu^0 + N_2^0 + 2H_2^{+1(+2)}O^{-2}$$

$$2 \rightarrow 0 \text{ REDUCTION}$$

N will oxidize because oxidation number is increased from -3 to 0 and **Cu** will reduce because oxidation number is decreased from +2 to 0.

Q#15 Define oxidation number or oxidation state.

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Oxidation state is defined as the number of charges an atom will have in a molecule or a compound.

The element which shows an increase in oxidation number is oxidized.

The element which shows a decrease in oxidation number is reduced.

Q#16 Find the oxidation state of nitrogen in the following compounds.

Oxidation number of N in no2:

The sum of oxidation numbers must be zero.

[O.N OF N] + 2[O.N OF O] = 0

[O.N OF N] + 2[-2] = 0

[O.N OF N] -4 = 0

[O.N OF N] = +4

THUS OXIDATION STATE IS +4.

Oxidation number of N in HNO3:

The sum of oxidation numbers must be zero.

[O.N OF H] + [O.N OF N] +3 [O.N OF o] = 0

[+1] + [O.N OF N] + 3[-2] = 0

[+1] + [O.N OF N] -6 = 0

[O.N OF N] -5 = 0

[O.N OF N] = +5

THUS OXIDATION STATE IS +5.

Oxidation number of N IN N2O:

The sum of oxidation numbers must be zero.

2[O.N OF N] + [O.N OF O] = 0

2[O.N OF N] + [-2] = 0

2[O.N OF N] -2 = 0

2[O.N OF N] = 2   [O.N OF N] = +1

THUS OXIDATION STATE IS +1

Oxidation number of N IN N_2O_3:

The sum of oxidation numbers must be zero.

2[O.N OF N] + 3[O.N OF O] = 0

2[O.N OF N] + 3[-2] = 0

2[O.N OF N] – 6 = 0

2[O.N OF N] = +6

[O.N OF N] = +3

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THUS OXIDATION STATE IS +3

Find the oxidation state of s in the following compounds.

Oxidation number of S IN H_2S:

The sum of oxidation numbers must be zero.

[O.N OF S] + 2[O.N OF H] = 0

[O.N OF S] + 2[+1] = 0

[O.N OF S] + 2 = 0

[O.N OF S] = -2

THUS OXIDATION STATE IS -2.

Oxidation number of S IN H_2SO_3:

The sum of oxidation numbers must be zero.

2[O.N OF H] + [O.N OF S] + 3[O.N OF O] = 0

2[+1] + [O.N OF S] + 3[-2] = 0

+2 + [O.N OF S] + 3[-2] = 0

2+ [O.N OF S] -6 = 0

[O.N OF S] – 4 = 0

[O.N OF S] = +4

THUS OXIDATION STATE IS +4.

Oxidation number of S IN $Na_2S_2O_3$:

The sum of oxidation numbers must be zero.

2[O.N OF Na] + [O.N OF S] + 3[O.N OF O] = 0

2[+1] + 2[O.N OF S] + 3[-2] = 0

+2 + 2[O.N OF S] -6 = 0

2[O.N OF S] -4 = 0

2[O.N OF S] = +4

[O.N OF S] =+2

THUS OXIDATION STATE IS +2.
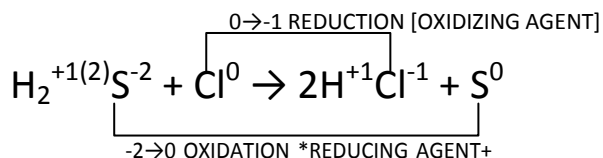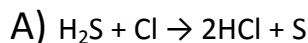
Q#17 Defines oxidizing and reducing agents.

Oxidizing agent

An oxidizing agent is the reactant containing the element that is reduced in a chemical reaction.
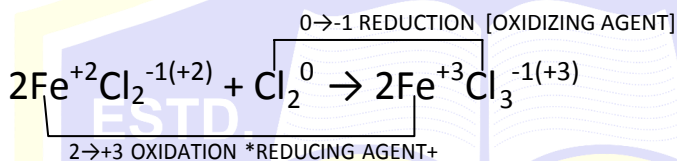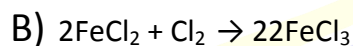
Reducing agent

A reducing agent is the reactant containing the element that is oxidized in a chemical reaction.

b) Identify the oxidizing agents and reducing agents in the following reactions:
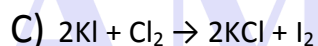
A) $H_2S + Cl \rightarrow 2HCl + S$

0→-1 REDUCTION [OXIDIZING AGENT]

$$H_2^{+1(2)}S^{-2} + Cl^0 \rightarrow 2H^{+1}Cl^{-1} + S^0$$

-2→0 OXIDATION *REDUCING AGENT+

S will oxidize so it is a reducing agent.

Cl will reduce so it is an oxidizing agent.

B) $2FeCl_2 + Cl_2 \rightarrow 22FeCl_3$

0→-1 REDUCTION [OXIDIZING AGENT]

$$2Fe^{+2}Cl_2^{-1(+2)} + Cl_2^0 \rightarrow 2Fe^{+3}Cl_3^{-1(+3)}$$

2→+3 OXIDATION *REDUCING AGENT+

Fe will oxidize so it is a reducing agent.

Cl will reduce so it is a oxidizing agent.

C) $2KI + Cl_2 \rightarrow 2KCl + I_2$

-1→0 OXIDATION [REDUCING AGENT]

$$2KI^0 + Cl_2^0 \rightarrow 2K^{+1}Cl^{1} + I_2^0$$

0→-1 REDUCTION [OXIDIZING AGENT]
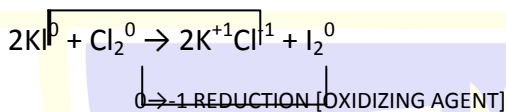
Cl will reduce so it is an oxidizing agent.

K will oxidize so it is a reducing agent.

D) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

0→+2 OXIDATION [REDUCING AGENT]

$$Mg^0 + 2H^{+1}Cl^{-1} \rightarrow Mg^{+2}Cl_2^{-1(+2)} + H_2^0$$

+1→0 REDUCTION *OXIDIZING AGENT+
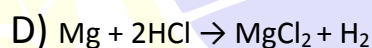
Mg will oxidize so it is a reducing agent.

H will reduce so it is an oxidizing agent.

Q#18 Is hydrogen peroxide an oxidizing or reducing agent in these reactions. Give your reason.

$H_2O_2 + Ag_2O \rightarrow 2Ag + H_2O + O_2$

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$$Ag_2^{+1(2)} O^{-2} + H_2^{+1(2)} O_2^{-1(2)} \rightarrow 2Ag^0 + H_2^{+1(2)}O^{-2} + O_2^0$$
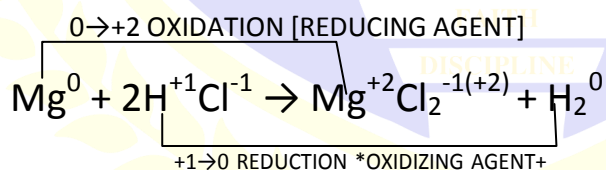
-1→0 OXIDATION [REDUCING AGENT]

+1→0 Reduction *OXIDIZING AGENT+

Ag will reduce so it is an oxidizing agent.

O will oxidize so it is a reducing agent.

$$4H_2O_2 + PbS \rightarrow PbSO_4 + 4H_2O$$

-2→+6 OXIDATION *REDUCING AGENT+

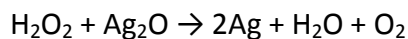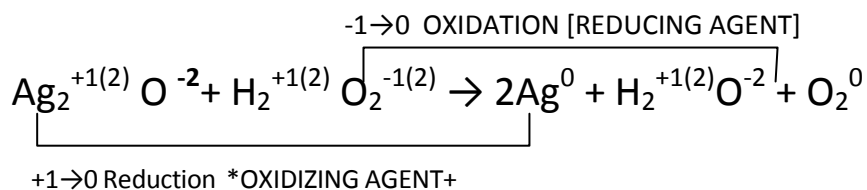$$4H_2^{+1(2)}O_2^{-1(2)} + Pb^{+2}S^{-2} \rightarrow Pb^{+2}S^{+6}O_4^{4(-2)} + 4H_2^{+2}O^{-2}$$

-1→-2 REDUCTION [OXIDIZING AGENT]
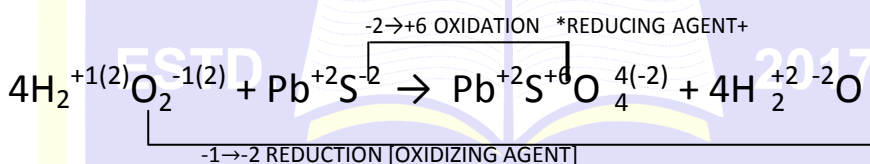
O will reduce so it is an oxidizing agent.

S will oxidize so it is a reducing agent.

THINK TANK:

Q1. What materials do you need to electro plate copper on to a nail? Make a diagram showing how these materials should be arranged.

- We need copper as anode.
- We need iron as cathode.
- We need $CuSO_4$ as electrolyte.
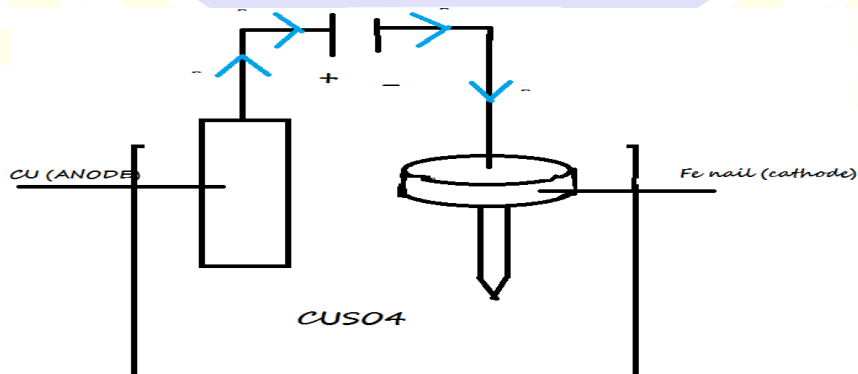
Q2. Describe the process that is occurring in the following illustration. Shoe has steel strips.

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Electroplating of Cu is occurring on steel.
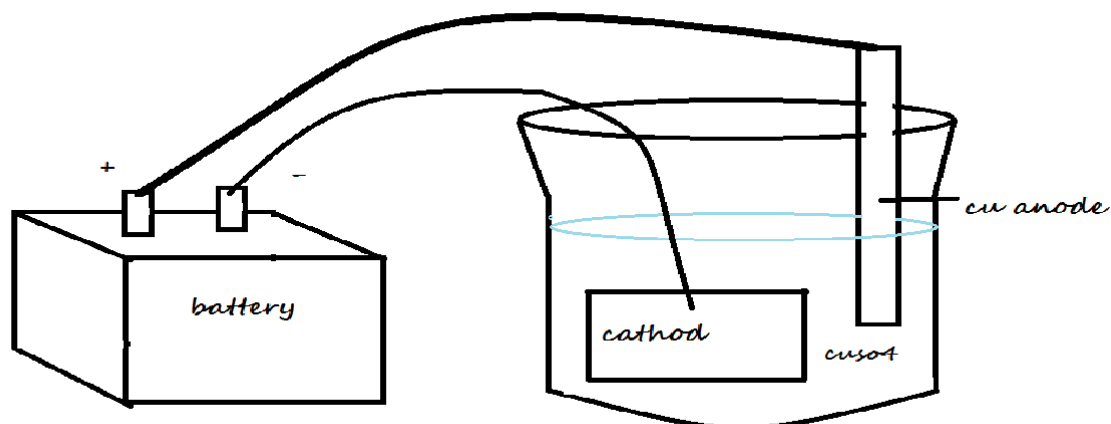
Q3. Following Redox reaction occurs in the following voltaic cell identify anode and cathode.
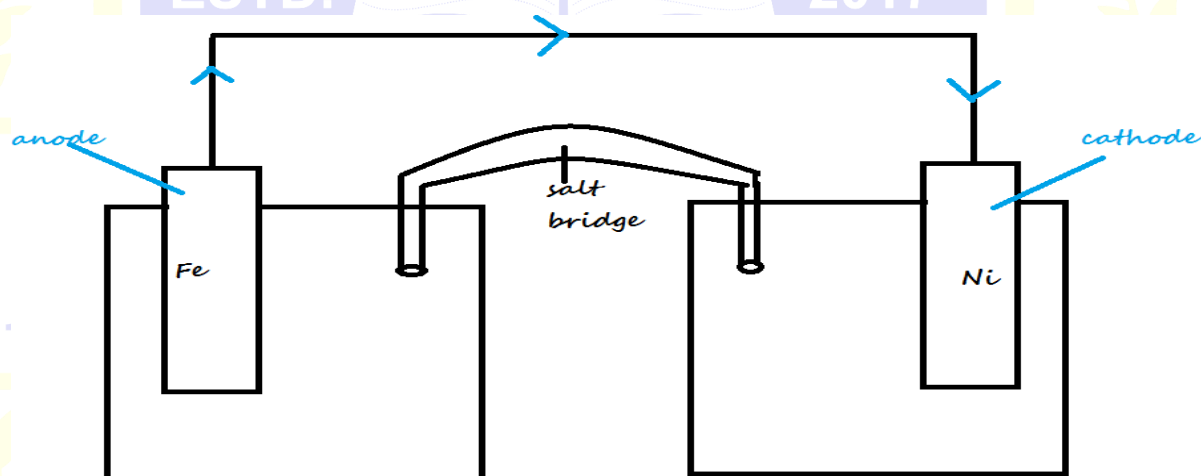
Q4. Design an experiment to demonstrate cathodic protection from corrosion.
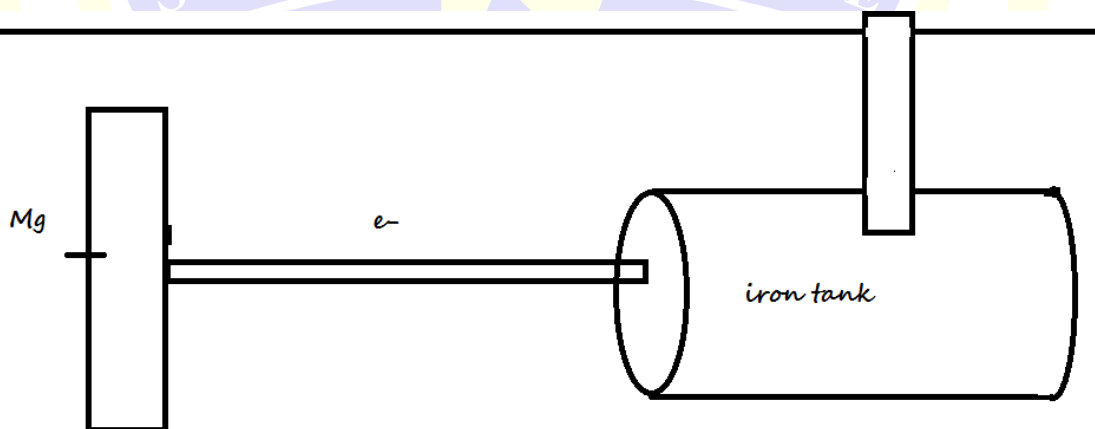
Cathodic protection is the process in which the metal that is to be protected from corrosion is made cathode and is connected to metals such as magnesium or aluminum. These metals are more active than iron, so they act as anode and iron as cathode. The more active metals themselves oxidize and

save iron from corrosion. Cathodic protection is employed to prevent iron and steel structures such as pipes, tanks, oil rigs etc in the moist underground and marine environment.

CHAPTER - 8

CHEMICAL REACTIVITY

Self Assessment :8.1:

Q:1: In each of the following pair identify, which element is more metallic?

(a)Be, B

Ans: Be, because metallic character is decrease along the period. Be is present before the B in period that's why Be is more metallic than B.

(b) Si, Al

Ans: Al, because metallic character is decrease along the period. Al is present before the Si in period that's why Al is more metallic than Si.

(c) K, Li

Ans: K, because metallic character increases along the group.

Q:2: using the periodic table rank each set of elements in order decreasing metallic character.

(a) Na, Li, K

Ans: K>Na>Li

(b) Al, Na, Mg

Ans: Na>Mg>Al

Metallic character decreases in period and increases in group.

Q:3: Which is more basic Li_2O or Na_2O?

Ans: Na_2O, because basic character is increase from top to bottom.

Self Assessment:8.2:

Identify the position of Mg and Ca in the periodic table.

Ans: Mg

Period: 3

Group: IIA

Ca

Period: 4

Group: IIA

Self assessment: 8.3:

1: In each of the following pairs, identify which element is less non- metallic.

(a)B or C

Ans: B, because non- metallic character increases along the period.

(b) C or Si

Ans: Si, because non-metallic character decreases from top to bottom.

(c) Cl or Br

Ans: Br, because non-metallic character decreases from top to bottom.

2: Using periodic table rank each set of elements in order of increasing non-metallic character.

(a) N, F, O

Ans: N<O<F

(b) Cl,Br,I

Ans: I<Br<Cl

(c) Si, S, P

Ans: Si<P<S

Self assessment: 8.4:

Which of the following displacement reaction will occur?

1: Cl_2 + 2NaF ⟶ 2.2NaCl + F_2

Ans: Displacement reaction will not occur, because Cl is less reactive than F_2.

Br_2 + 2KI ⟶ 3.2KBr + I_2

Ans: Displacement reaction will occur, because Br is more reactive than I_2.

I_2 + 2KBr ⟶ 2KI + Br_2

Ans: Displacement reaction will not occur, because I_2 is less reactive than Br_2.

Cl_2 + 2KBr ⟶ 5.2KCl + Br_2

Ans: Displacement reaction will occur, because Cl is more reactive than Br_2.

Cl_2 + 2NaI ⟶ 2NaCl + I_2

Ans: Displacement reaction will occur, because Cl is more reactive than I_2.

REVIEW QUESTIONS

Q.2: Give short answers:

(i) In a group the reactivity of the metals with oxygen increases? Give example.

Ans: In a group the reactivity of metals with oxygen increases. For instance alkali metals on exposure to air show an increase in affinity for oxygen as move down the group.

Lithium forms normal oxide.

$4Li + O_2 \longrightarrow 2Li_2O$

Sodium forms per oxide.

$2Na + O_2 \longrightarrow Na_2O_2$

K, Rb, Cs forms super oxide.

$K + O_2 \longrightarrow KO_2$

(ii) Which element is more metallic Mg or Al? Explain.

Ans: Mg is more metallic, because metallic character is decrease in period. Mg is present before the Al in periodic table along the period that is why Mg is more metallic than Al.

(iii) What is the importance of Mg?

Ans: Magnesium has relatively low density and it is used in making light weight alloy with aluminum that are used for making frames of automobiles, air craft, and spaceship, cameras etc. since magnesium burns brilliantly, it is used in photo flash guns. $Mg(OH)_2$ called milk of magnesia is commonly used as antacid(an agent that neutralize acidity especially in stomach).

(iv) Arrange the following in order of increasing acidic strength

HF, HI, HBr, HCl

Ans: HF<HCl<HBr<HI

(v) can F_2 oxidize all the halide ions to free halogen?

Ans: yes F_2 can oxidize all the halide ion to free halogen. Oxidizing power of F_2 is highest.

Q.3: Arrange the following oxides in order of decreasing basic character.

BeO, CaO, MgO, SrO

Ans: SrO>CaO>MgO>BeO

Q.4: Rank the each of element in order of increasing metallic character.

(a) Al, Na, K

Ans: Al<Mg<Na

(b) Na, Li, K

Ans: Li<Na<K

Q.5: Which of the following displacement reaction will not occur? Give reason.

(a) $Cl_2 + 2NaF_2 \longrightarrow 2NaCl + F_2$

Ans: Displacement reaction will not occur, because Cl_2 is less reactive than F_2.

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(b) $Br_2 + 2KI \longrightarrow 2KBr + I_2$

Ans: Displacement reaction will occur, because Br_2 is more reactive than I_2.

(c) $I_2 + 2KBr \longrightarrow 2KI + Br_2$

Ans: Displacement reaction will not occur, because I_2 is less reactive than Br_2.

Q.6: Give some important application of platinum.

Ans: platinum is widely used as catalystfor many types of industrial processes. For example 100% pure sulphuric acid is prepared by the contact process. In this process platinum is used as catalyst. Platinum is used as electrode as a part of hydrogen electrode and in fuel cells. Automobiles exhaust is a major source of air pollution. Therefore, most new cars are equipped with catalytic converters. These converters contain platinum. These converters catalyze the complete combustion of CO and hydrocarbons. A platinum compound called cis-platin is useful as an anti cancer agent.

Q.7: What is half reaction?

Ans: A half reaction is either the oxidation or reduction reaction component of a redox reaction.

Q.8: What is aqua regia?

Ans: Aqua regia is a mixture of 3 parts by volume of conc HCl and one part by volume of conc HNO_3.

Think thank

Q.1: why it is advisable, not to pick sodium metal with fingers.

Ans: Sodium is very reactive. It reacts with water and proceed light explosion. It should not be picked with finger. Finger have moisture, sodium react violently with moisture and burn our fingers.

Q.2: How do electrons participate in half reaction?

Redox reactions are comprised of two parts, a reduction half reaction and oxidation half reaction that always occur together. The electrons are either loose (oxidation half reaction) and gain (reduction half reaction).

Q.3 Design an experiment to show that iron is more reactive than copper. From text book

Q.4: How are voltaic cell and electrolytic cell alike, and how are they different?

Ans: From Chapter no. 7

Q.5: An iron bar is to be silver plated which metal would be the anode and which the cathode?

Ans: An iron bar is to be silver plated. In this process iron bar will be cathode and silver will be anode.

Q.6: Compare corrosion of Al and Fe.

Ans: From Chapter no. 7 (7.7.2)

Q.7: Compare and contrast alkali and alkaline earth metals.

Ans: Article (8.1.2)

Q.8: Compare three metals that would not be suitable for coinage.

Sodium, Gold and Platinum would not be suitable for coinage because

- **sodium cannot be picked by hands, as it is highly reactive.**
- **Gold is expensive**
- **Platinum is also expensive and rare.**