**MARKING SCHEME,CHEMISTRY(2019) (100 marks)**

**S4, SECTION A: (70 marks)**

1. a) The electronic configuration of FeandFe2+ in terms of s, p, d and f notation. **(2 marks)**

Fe: 1S22S2 2P6 3S2 3P6 4S2 3d6

Fe2+ : 1S22S2 2P6 3S2 3P6 4S0 3d6

**(Give 1 mark for each answer)**

**(Accept representation of electrons using arrows in boxes)**

b) The atomic mass and its % abundance of each isotope of zirconium are given in the table below. **(3 marks)**

The RAM of Zr :$\frac{\left(90X51.5\right)+\left(91X11.2\right)+\left(92X17.1\right)+\left(94X17.4\right)+(96X2.8)}{100}$

The RAM of Zr = **91.318**

**(Give 2 marks for the method and 1 mark for the final answer)**

2.a) Bohr postulates of an electron in an atom (Bohr atomic model) **(3 marks)**

-An electron can rotate around the nucleus in certain fixed orbits of definite energy without emission of any radiant energy.

-An electron can make a transition from its stationary state of higher energy to a state of lower energy and emit a single photon of frequency υ

- An electron can make a transition from its stationary state of lower energy level to the higher energy level and absorb energy.

**(Give 1 mark for each point above)**

b) An electron is excited from energy level 2 of an atom to energy level 4.

i) The wavelength of light of this emission.**(3 marks)**

 (C=3 x 108 ms-1 )

$\frac{1}{λ}$ = Rh($\frac{1}{2^{2}}$ - $\frac{1}{4^{2}}$) = 109678($\frac{3}{16}$)

$\frac{1}{λ}=$20564.6 cm-1

$λ$= 4.8627 X 10-5 cm = 4.8627 X 10-7 m

Since 1 m = 109 nm

$λ$**=486.27 nm**

**(Give 2.5 marks for the method and 0.5 mark for the final answer)**

3.a)The nature of an ionic bond. **(2 marks)**

-An ionic bond is formed by electrostatic attraction between two or more oppositely charged ions.

-Ionic bonds are strong to break.

b) State 3 properties of ionic compounds. **(3 marks)**

-They are brittle

-They have high melting points and boiling points

-They conduct electricity when they are dissolved in water.

**(Accept other correct answers)**

**(Give 1 mark for each correct statement)**

4. The diagram of PCl3 molecule indicating unshared electrons. **(2 marks)**



**(Give 1 mark for the structure and 1 mark for the lone pair)**

(Atomic number: P = 15, Cl = 17)

5.a) One difference between p-block elements and d-block elements by giving examples of elements of each block. **(2 marks)**

-The p-block elements have their valence electrons in the p orbital, an example is sulphur.

-Thed-block elements have their valence electrons in the d orbital, an example is iron.

**(Accept other correct answers)**

b) The variation in electronegativity in period 3 of the periodic table from Na to Ar. **(2 marks)**

-Electronegativity increases across period 3because the **number of charges in the nucleus increases** which **increase the nuclear-electron attraction** towards the nucleus.

-The increase in nuclear-electrons attraction in atoms **outweighs the screening effect** of electrons as you move across the period.

**(Give 1 mark for each statement given above)**

6.a) One difference in thermal decomposition of KNO3 and LiNO3**(2 marks)**

-KNO3 decomposes to form KNO2 and O2 gas whereas LiNO3 decomposes to form Li2O , NO2 and O2

b) The colour of the flame (flame test) of :**(3 marks)**

i) LiCl : Dark red

ii) NaCl: Yellow

iii) KCl : Purple or Lilac

**(Give 1 mark for each correct answer)**

7.a)The trend in solubility of sulphates of group 2 elements down the group. **(2 marks)**

**-**As you move down the group, the hydration enthalpy decreases faster than the lattice enthalpy

-Therefore the solubility of group 2 sulphates decreases as you move down the group.

**(Give 1 mark for each correct explanation)**

b) Reagent you can use to differentiate Mg2+ ions and Ca2+ ions: SO42- orsulphate. **(1 mark)**

Observable change in each case: There is formation of a white precipitate for Ca2+ but not with Mg2+ ions. **(1 mark)**

**(Accept other correct answers)**

8.a) Equation between :

i) Aluminium and dilute aqueous HCl **(1 mark)**

2Al(s) + 6HCl(aq) → 2AlCl3(aq) + 3H2(g)

ii) Aluminium and NaOH in aqueous solution. **(1 mark)**

2Al(s) + 6H2O +2NaOH(aq) → 2NaAl(OH)4 + 3 H2(g)

**(Give 1 mark for each correct equation)**

**(Give 0.5 mark for unbalanced equation)**

**(Neglect state symbols while awarding marks)**

b) 2 differences in chemical reactions of boron and aluminium. **(2 marks)**

-Oxides of boron are acidic while that of aluminium is amphoteric

-Dilute acids do not react with boron but they react with aluminium

-Concentrated nitric acid oxidises boron to boric acid but not with aluminium.

**(Give 1 mark for each of the two answers)**

**(Accept other correct answers)**

c) Give 2 advantages to suggest why aluminium is used to make electric wires. **(2 marks)**

-Aluminium is resistant to corrosion

-Aluminium has a low density.

**(Give 1 mark for each of the two answers)**

**(Accept other correct answers)**

9.a) i) The equation of the reaction between Pb and dilute HNO3 . **(1 mark)**

-With concHNO3 :

Pb(s) + 4HNO3(aq) →Pb(NO3)2(aq) + 2NO2(g) + 2H2O(l)

**or**

-With dilute HNO3 :

3Pb(s) + 8HNO3(aq) → 3Pb(NO3)2(aq) + 2NO(g) + 4H2O(l)

ii) The equation of the reaction between Pb and hot concentrated NaOH solution. **(1 mark)**

**Pb(s) + 2OH-(aq) + H2O(l) → PbO32-(aq) + 2H2(g)**

b) The thermal stability of group 14 tetrachlorides decreases down the group from CCl4 to PbCl4 because:

-The bonds between group 14 atoms and chlorine **become longer** and **weaker** as you move down the group. **(2 marks)**

10. a) The equation of the reaction between P and oxygen . **(2 marks)**

4P(s) + 5O2(g) → 2P2O5(s)

**Or**

4P(s) + 5O2(g) → P4O10(s)

**(Give 1 mark for any of the above answers)**

b) 3 special conditions required for optimum production of ammonia gas NH3 in the Haber process. **(3 marks)**

-Temperature of 450 0C

-High pressure of 200 atmospheres

-Iron catalyst

**(Give 1 mark for each of the above answers)**

11. a) A test reagent that can be used to identify S2O32- and the observable changes. **(2 marks)**

**-**Reagent: Dilute HCl acid

-Observation: There is formation of a white precipitate after a few minutes which intensify with time.

**(Give 1 mark for the reagent and 1 mark for the observation)**

b) 2 uses of H2SO4 on a large scale. **(2 marks)**

**-**In vehicle batteries

-Electrolysis of copper during the purification process.

**(Give 1 mark for each answer)**

**(Accept other correct answers)**

12.a) The trend in solubility of group 17 elements in water (F2, Cl2, Br2, I2 ) **(2 marks)**

-Solubility of halogens in water decreases as you move down the group.

-As the size of halogen atoms become bigger, the nuclear attraction of hologenswith hydrogen of H2O molecule decreases and the polarity of small charges on the halogen decreases.

-So down the group, the molecules become more and more covalent and therefore non-polar which reduces the solubility in polar water.

b) Write the equation of the reaction between I2 and hot concentrated NaOH.

**(2 marks)**

3I2+ 6OH- → IO3- + 3H2O + 5I-

**(Accept a molecular equation)**

**(Give 1 mark for unbalanced equation)**

13.a) 2 uses of noble gases. **(2 marks)**

-Noble gases are used in lamps

-Noble gases are used in LASER radiations for many purposes such as in computers to read recorded information.

**(Accept other correct answers)**

**(Give 1 mark for each answer)**

 b) H2O is liquid at room temperature but H2S is a gas despite H2S having a higher molecular mass:**(2 marks)**

-It is because oxygen is very electronegative thus it creates partial negative charges on oxygen and partial positive charges on hydrogen.

-This difference in partial charges results into strong inter-molecular forces of hydrogen bonds in H2O while there are weak inter- molecular forces of van-der-waals in H2S.

14. a) Le Chatelier principle about the pressure effect on reactions of gases.**(2 marks)**

**-**Le Chatelier principle states that if a constraint such as change in pressure or temperature is applied to a system in equilibrium, the equilibrium will shift so as to counteract the effect of the constraint.

b) The importance of the catalyst used in the reacting mixture of H2 and N2 to produce NH3is to speed the reaction at a low temperature so that maximum yield of ammonia may be obtained. **(2 marks)**

15.a) The vapourised sample passes into the **ionization chamber with a high positive voltage**.

The **electrically heated metal coil gives off electrons** which are **attracted to the positively charged electron plate**.

 The particles in the sample atoms or molecules **are bombarded with a stream of electrons** and the **collisions are so energetic that they knock out electrons** out of the sample particles **to make positive ions**. **(3 marks)**

**(Give 0.5 mark for each underlined statement)**

**(Accept other correct explanations)**

b)The trend in oxidising ability of the elements down group VII(a) from fluorine to iodine:

The halogens **decrease in oxidizing power as you move down the group**. This is due to the fact that as you move down the group, **the atom size increases** and the **nuclear attraction of the outermost electrons decreases**. **(2 marks)**

**(Give 1 mark for the first underlined statement and 0.5 mark for each of the other underlined statements)**

**(Accept other correct answers)**

16.a) Equation for the reaction:**(2 marks)**

**2KBr +3H2SO4 → 2KHSO4 + Br2 +SO2 +2H2O**

**(Give 1 mark for unbalanced equation)**

b) The role of sulphuric acid in this reaction is **to oxidise bromide ions to bromine molecule**. **(1 mark)**

**(Accept any other correct answer)**

**SECTION B: Each question is10 marks**

17.a) C(s) + CuO(s) → CO(g) + Cu(s)

i)The oxidizing agent in the equation: **CuO (1 mark)**

ii)The total mass of the solid mixture **reduces** at the end of the reaction.**(1 mark)**

b) Balance the following equation: **(2 marks)**

 Over-all equation:

 2MnO4-(aq) + 6H+(aq) + 5H2O2(aq) → 5O2(aq) + 2Mn2+(aq) +8 H2O(l)

**(Give 1 mark for the method and 1 mark for the final answer)**

c) First law of thermodynamics states that energy **cannot be created** nor **destroyed** in an isolated system. **(2 marks)**

d) The enthalpy of combustion ∆H4 for the following reaction: **(4 marks)**

C3H8(g) + 5O2(g) → 3CO2(g) + 4H2O(l) ∆H4 = ?

3∆H1 + 4∆H3 = ∆H2 + ∆H4

 ∆H4 = 3∆H1 + 4∆H3 -∆H2

 ∆H4 = (-393X3) +(-286X4) –(-104.7)

 The enthalpy of combustion ∆H4 = **-2218.3 KJ/mole**

**(Give 3 marks for the method and 1 mark for the final answer)**

18.a) A chemical reagent that you would use to distinguish between Mg2+ and Zn2+ ions in solution:

Reagent: NaOH solution

Observation: Mg2+ ions solution reacts with NaOH solution **to produce a white precipitate that is insoluble in excess of NaOH**.

Zn2+ ions solution reacts with NaOH solution **to produce a white precipitate**. The **precipitate dissolves in excess of NaOH** solution.**(3 marks)**

**(Give 1 mark for each underlined statement)**

**(Accept other correct reagents and correct observations)**

b) Atomic radius decreases across the third period, from sodium to chlorine because:

There is an **addition electrons as you move from left to right** in a period. There is an **addition of protons as you move across the period** which **increases the nuclear attraction of electrons towards the nucleus**. The **nuclear attraction outweighs the shielding effect** of electrons such that the radius decreases across the period. **(2 marks)**

**(Give 0.5 mark for each underlined statement)**

**(Accept other correct answers)**

c) The structure and bonding in diamond carbon affect its melting point:

Each carbon is **covalently bonded to 4 other carbon atoms** forming a **giant tetrahedral structure** which makes it **very hard with a high melting point.(3 marks)**

**(Give 1 mark for each underlined statement)**

**(Accept other correct answers)**

d) Metals are malleable but ionic crystals are not malleable but brittle in nature:

**(2 marks)**

-This is because **electrons are moving** and the **layers of atoms can slide over one another into new positions** without breaking the metallic bond when the metal is bent, hammered or pressed.

-Crystals are brittle due to **strong ionic bonding throughout the crystal.**

If the layer was to slip upon exerted force, **charges of the same sign would face each other, start repelling each other** and finally break apart by cleavage.

**(Give 0.5 mark for each underlined statement)**

**(Accept any other correct answer)**

19. a)The first ionisation energy of an element is the **energy required to remove one mole** of the most loosely held **electrons fromone mole** of gaseous atoms **to produce one mole of gaseous ions** each with a charge of 1+ . **(2 marks)**

**(Give 0.5 mark for each underlined statement)**

**(Accept other correct descriptions)**

b) The **first ionisation energy decreases down the group** from carbon to lead because **there is addition of shells down the group** such that the outermost electrons are **too far from the nuclear charge attraction** and therefore **become more loosely held** as you move down the group. **(2 marks)**

**(Give 0.5 mark for each underlined statement)**

**(Accept other correct answers)**

c) The melting points of group 14 elements generally decrease down the group from carbon to lead because **inter atomic bonding between the larger atoms reduce in strength** as you **move down the group.(2 marks)**

**(Give 1 mark for each underlined statement)**

**(Accept other correct answers)**

d) Two materials made in graphite: **(2 marks)**

-Pencil

-Lubricant in moving parts of machines.

**(Give 1 mark for each underlined statement)**

**(Accept other correct answers)**

e) Beryllium shows different chemical or physical properties from other elements of group II:**(2 marks)**

- Beryllium forms amphoteric oxides while other metal oxides of the same group form basic oxides.

- Beryllium chloride is soluble in organic solvents while other metal oxides of the same group are insoluble in organic solvents.

**(Give 1 mark for each correct answer)**

**(Accept other correct answers)**

20. a) The term “standard enthalpy of neutralization”. **(2 marks)**

The standard enthalpy of neutralization is the enthalpy change when solutions of **an acid** and **an alkali** react together under standard conditions **to produce 1 mole of water**.

**(Give 0.5 mark for the first two underlined statement and 1 mark for the third)**

b) The standard enthalpy of neutralization of the acid. **(4 marks)**

Number of moles of H2O produced=$\frac{1}{1000}$X25 =0.025 mole

Change in temperature= 28.2-21.5 =6.7 0C

Mass of solution=25+25= 50g

Heat liberated= ∆t

∆t=4.18X6.7X50 = 1400.3 Joules

Standard enthalpy of neutralization= $\frac{1400.3}{0.025}$ = 56012 Joules

**Standard enthalpy of neutralization= 56.012 KJ/mole**

**(Accept other correct methods)**

**(Give 3 marks for the method and 1 mark for the final answer)**

c) 2 factors that influence the strength of a covalent bond. **(2 marks)**

-Bond length

-Polarity of bonds

-Presence of lone pairs

-Number of bonds between atoms

-Size of atom

**(Give 1 mark for each correct answer)**

**(Consider 2 answers when awarding marks)**

d) i) “Hess”law” of constant heat summation states that the change of enthalpy in a chemical reaction **is independent of the pathway between the initial and the final states**. **(1 mark)**

**(Accept other correct definitions)**

ii) Chemical equations to describe how Hess”s law is applied. **(1 mark)**

∆HӨ(reaction) =ΣӨf(products)- ΣӨf(reactants)

**(Accept other correct equations)**

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