CHEMISTRY OLYPIAD QUESTIONS JETS 2O12

QUESTION 1.

In an experiment 0.625 mol of N2O4 was introduced into a 1dm3 vessel and allowed to reach equilibrium was 0.075 mol/dm3,temperature 300K.

(a)What is the equilibrium concentration of NO2 [5]

(b)Calculate KC for the reaction N2O4 2NO2 [3]

(c)What is Kc for the backward reaction [3]

(d)Calculate the Kp for the reaction [4]

 Total[15]

QUESTION 2

(a)Outline the major features of a liquid state [3]

(b)On the basis of the kinetic molecular theory, explain the process of evaporation [3]

(c)The vapour pressure at 20oC of benzene, water and mercury is given below

 Benzene-74.4mmHg

 Water-17.5mmHg

Mercury-0.0012mmHg

(i)arrange the substances in order of increasing rate of evaporation the least first [3]

(ii)state and explain which substance would have the highest boiling point [3]

(d)A sample of oxygen gas initially at s.t.p is transferred from a 2dm3 container to a 1dm3 container at constant temperature. State giving reasons the effect of this change on the:

(i)The average speed of the oxygen molecules [1]

(ii)The total number of collisions of oxygen molecules with the wall of the container in a unit of time[2]

Marking Guide

Question 1

(a) N2O4 2NO2 [2]

Initial concentration=0.625 mol/dm3

Equilibrium concentration=0.625-0.075 =0.55\*2

N2O4 2NO2

O.O75mol/dm3 1.10 mol/dm3 [3]

(b) KC= [NO2] [1]

 [N2O4]

KC=(1.10)2

 0.075

KC=1.21

 0.075

KC=16.13mol/dm3  [2]

(c)Kc for the backward reaction, find the reciprocal of the forward reaction 1/16.13 =0.062mol/dm3

(d)calculate the Kp for the reaction

Kp=Kc(RT)n [2]

Kp=16.13 ×8.31 ×300

 =40212.09 J/dm3

Question 2

(a) liquids have a fixed volume

 -liquids have no fixed shape

-liquids are non- compressible [3]

(b) when the liquid molecules gain energy they become mobile as a result they are able to overcome the attractive forces and they are lost. [3]

(c)(i)mercury, water, benzene [3]

 (ii)mercury will have the highest boiling point. This is because in mercury the amount of heat needed to break the forces of attraction is high [3]

(d)(i)the speed will be the same because the temperature is constant [1]

(ii)the rate of collision will increase because the volume has been increased [2]

QUESTION 3

(a)What determines the position of an element in the periodic table? [1]

(b)(i)What is electron affinity of an element? [1]

 (ii)Two elements A and B are in the same periodic table. They are non-metallic and there are two other elements between them. Element A is on the left of element B.

(a)Which of the two has higher electron affinity? [1]

(b)Give two reasons for your answer above [2]

(c)Element M is in group I and element N is in group II.

(i)Give any two expected physical differences between them. [2]

(ii)Write the chemical formulae for the carbonates of both metals. [2]

(iii)Compare and contrast the thermal stability for two carbonates in (c)(ii) above. [3]

(d)Ammonia gas is manufactured by the direct combination of nitrogen and hydrogen gas.The reaction is reversible.

(i)What is a reversible reaction? [1]

(ii)How does temperature affects the yield of ammonia gas in this reaction? [2]

ANSWERS TO QUESTION 3

(a) Number of electrons in outer shells

(b)(i)Readiness or ability of an atom to accept electrons.

 (ii)(a) B

 (b)-more electronegative

 -more number of electrons in the outermost shells.

 -bigger atom.

(c)(i)Group I have low melting and boiling points compared to group II

 Group I are soft metals than group II

 Group I are silvery and group II are white

 (ii)- M2CO3

 -NCO3

(iii) M is more stable than N and they do not easily decompose on heating.

 NCO3→NO + CO2 while M2CO3 does not decompose

(d)(i) is a reaction where a forward and backward reaction take place at the same time.

QUESTION 4

(a)Define the following terms;

(i)Electrolysis[1]

 (ii)Electrolyte[1]

 (iii)Electrode[1]

(b)Give any two factors that may determine preferential discharge of a particular type of ion.[2]

 (c)Write down the chemical equations representing reactions that may take place at the anode and cathode under the following conditions:

(i) Concentrated sodium chloride using graphite electrodes [3]

(ii)Dilute sulphuric acid using inert electrodes [3]

(iii)Dilute aqueous copper(II)sulphate using inert electrodes. [3]

(d)As electrolysis goes on in C(iii)what would be observed? [1]

ANSWERS TO QUESTION 4

(a)(i)Electrolysis is the decomposition of an electrolyte by the passage of an electric current through it[1]

(ii)Electrolyte is a solution which conducts electric current and be decomposed by it.[1]

(iii)Electrodes are points through which electric enter or leave the electrolyte.

(b)-concentration

 -position in the electrochemical series.

 -Electrode potential.

(c)(i)2Cl-→Cl2+2e-(anode)

 H2→2H++2e-(cathode)

 (ii)H2→2H++2e-(cathode)

4OH-+ 4e-→O2+ 2H2O(anode)

Cu2++2e-→Cu(cathode)

4OH-+4e-→O2+2H2O(anode)

QUESTION 5.

(a)(i)Which of the following atoms are of elements that are in the same period?

 Al13,O8 and S16 [1]

(ii)Give a reason for your answer in a(i) [1]

(b)(i)Which of the two atoms has a larger atomic radius?

 P15 and S16  [1]

(ii)Give a reason for your answer in (b)(i) [1]

(c)For the following Na11 and K19-

(i)Which of the two atoms has a higher first ionization energy? [1]

(ii)Give two reasons for your answer in (c)(i) [2]

(d)How many atoms of:

(i)Magnesium are in 3g of magnesium? [2]

(ii)Oxygen are in 4g of oxygen gas? [2]

(iii)Phosphorus are in 0.015 moles of phosphorus? [2]

(e)The chemical formula for aluminum sulphate is Al2(SO4)3.How many

(i)Aluminium ions dissociate in aqueous solution? [1]

(ii)Oxygen atoms are in 3.42g of aluminium sulphate? [1]

ANSWERS TO QUESTION 5

(a)(i) Al and S

 (ii) Same number of shells

(b)(i) S

 (ii)It increase the radius for an extra electron to have enough room for electron spin.

(c)(i) K-

 (ii)It needs a lot of energy to release an extra electron from the third shell.

 It has a stable structure like that of a noble gas.

(d)(i)24g of Mg→6×1023 atoms

 3g→x

X=7.5×1022atoms

(ii)32g of O→6×1023atoms

 4g→x

X=7.5×1022atoms

(iii)0.015×6×1023=9×1021atoms

(e)(i)2 ions

 (ii)27×2=54

 32×3=96

 16×12=192

 342

=0.0096g

QUESTION 6

(a)Define an acid according to GN Lewis. [2]

(b)Write Lewis reactions between BF3 and NH3. [3]

(c)What are the concentration and pH of 0.01mol/dm3 solution of benzoic acid,C6H5COOH? Ka=6.3×10-3mol/dm3. pH=[3],concentration=[2]

(d)What is the pH of a solution of ammonia,NH3 of concentration 0.10mol/dm3,given that

 Kb=1.7×10-5mol/dm3. [3]

(e)Write Lewis structures of (i)NH4- (ii)H3O+  [2]

ANSWERS TO QUESTION 6

(a) An acid is an electron-pair acceptor.

(c)C6H5COOH→C6H5COO- + H+

 [H+]=√Ka×[C6H5COOH]

 [H+]=7.937×10-3mol/dm3 [3]

 pH= -log[H+]

 =2.1 [2]

(d) pOH= -log√Kb×[NH3]

 =-log√1.7×10-5×0.1

 pOH=2.88

pH=14-pOH

 14-2.88=11.12

(e)

 

QUESTION 7

(a)Determine the oxidation state of the underlined atom in:

 (i)Na2Cr2O7 (ii) SbCl3 [2]

(b)Balance the redox reaction in alkaline solution

 MnO2-4 + N2H4→MnO+N2 [5]

(c)Balance the redox reaction in acidic solution

 Cu + H++NO3-→Cu2+ + 2NO3- + H2O +NO [5]

(d)What is the percentage by mass of hydrochloric acid contained in a solution of 10M HCl at 250C? specific gravitation of HCl is 1.19g/cm3 [3]

ANSWERS TO QUESTION 7

(a)(i)(1×2)+(-2×7)+2Cr=0

 Cr=+6

 (ii) (-1×3)×Sb=-3

 Sb=0

(b) MnO4-→MnO

 N2H4→N2

3H2O+MnO4-→MnO+6OH-

4OH-+ N2H4→N2 +4H2O

3H2O+MnO4-+5e-→MnO+6OH- ×4

4OH-+N2H4→N2+4H2O+4e- ×5

4MnO4-+5N2H4→4MnO+5N2+8H2O+4OH-

(c)Cu +H++NO3-→Cu2++2NO-3+H2O+ NO

 Cu→Cu2+

NO-3→NO

Cu→Cu2+

4H++ NO-3→NO+2H2O

3Cu→3Cu2++6e

6e+8H++NO-3→2NO+H2O

3Cu+2NO-3+8H+→3Cu2++2NO+ H2O

(d)



x/100=10.8×36.5/1.19×1000

x=33.1%

QUESTION 8

(a)Boron consists of 19.91% of the isotope B510 with atomic mass 10.013 and 80.09% of the isotope B511 with atomic mass11.009.Find the relative atomic mass of naturally occurring boron [3]

(b)2.00g of an organic compound gave upon complete combustion 4.86g CO2 and 2.03g H2O. The compound contains C,H and O only. What is the empirical formula of the compound? [4]

(c)Combustion analysis of 1.00g of an organic compound yields 2.75g CO2.The compound contains C and H only. Calculate the molecular mass as 88. [4]

(d)Explain why

 (i) K has a larger radius than K+ [1]

 (ii)Cl has smaller radius than Cl- [1]

(e)How many electrons have

 (i)NH4+ (ii) [(NH3)4Na]+ [2]

ANSWERS TO QUESTION 8



 =10.811 of natural boron

(b)mass of C=1.33g of C,mass of H=0.22g of H,mass of oxygen=0.45g of O

 C H O

 1.33/12 0.22/1 0.45/16

C=4,H=7 and O=1

Empirical formula C4H7O

(c)mass of C=0.75g, mass of hydrogen=2.75-0.75=2.0g of H [2]

C H

0.75/12=0.0625/0.0625=1 2.0/1=2/0.0625=32 [1]

Empirical formula CH32

Molecular formula=empirical formula × n n=molar mass/empirical=88/44=2

 =(CH32)n

 =(CH32)2

 =C2H64

(d)(i) K+ has greater nuclear attraction parent atom K causing shrinkage in the size of K+ as compared to K.

(ii)Cl- has more attraction cloud causing it to bulge than Cl.

(e)(i)NH4+=10 electrons (ii)[(NH3)4Na]+