



Our country, our future

525/1

S6 CHEMISTRY

Exam 18

PAPER 1

DURATION: 2 HOUR 45 MINUTES

Instructions to candidates:

Answer all questions in section A and six questions in section B.

All questions are to be answered in the spaces provided.

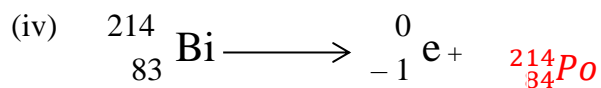
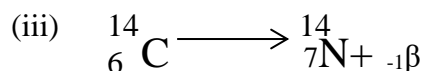
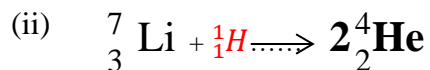
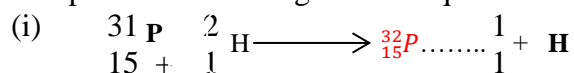
The periodic table, with relative atomic masses, is supplied at the end of the paper.

Mathematical tables (3 figure tables are adequate) or non-programmable scientific electronic calculators may be used.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total

SECTION A: (46 MARKS)

1. (a) Complete the following nuclear equations (2 marks)



(b) The half life of bismuth is 19.7 minutes. Determine the time taken for 75% by mass of the bismuth to decay (3 marks)

$$\lambda = \frac{\ln 2}{19.7} \text{ min}^{-1}$$

$$\text{From } \ln \frac{N_0}{N} = \lambda t$$

$$\ln \frac{100}{25} = \frac{\ln 2}{19.7} t$$

$$t = 39.4 \text{ min}$$

2. (a) Explain what is meant by the term oxidation number (1 m)

Oxidation number, the total number of electrons that an atom either gains or losses in order to form a chemical bond with another atom

- (b) Determine the oxidation number of

- (i) sulphur in $\text{S}_2\text{O}_8^{2-}$ and SO_4^{2-}

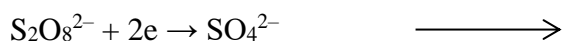
$\text{S}_2\text{O}_8^{2-}$ oxidation number of S = 7

SO_4^{2-} oxidation number of S = 6

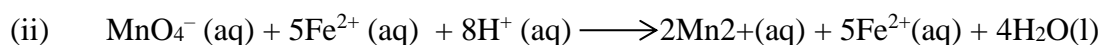
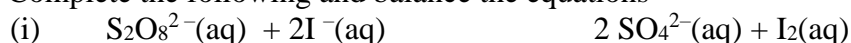
- (ii) Manganese in MnO_4^-

+7

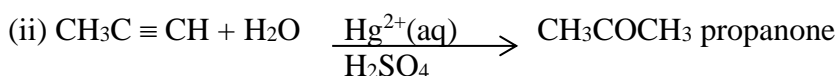
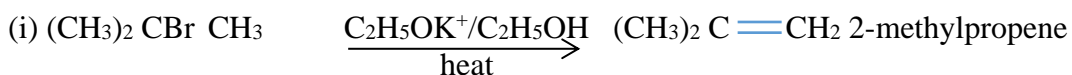
- (c) Write the half equation for the conversion of $\text{S}_2\text{O}_8^{2-}$ to SO_4^{2-} (1 mark)

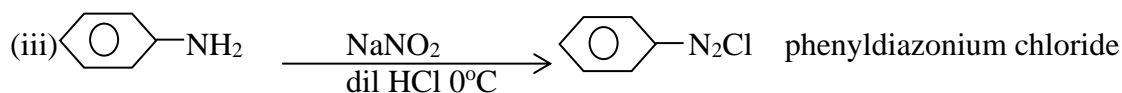


- (d) Complete the following and balance the equations

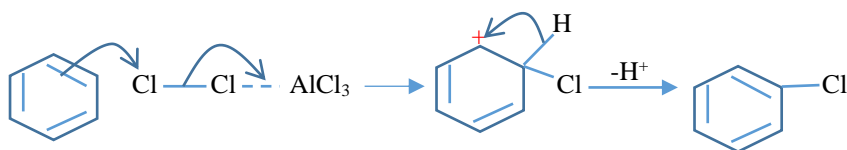
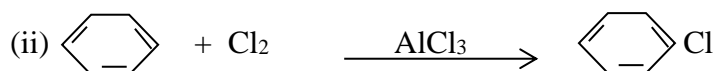
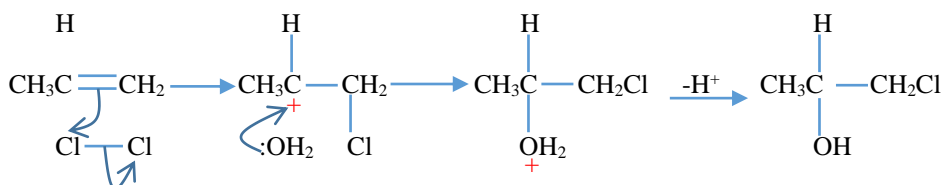
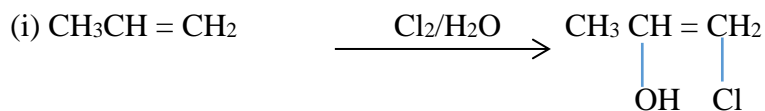


3. (a) Complete the following equations and in each case give the IUPAC name of the main organic product (1 mark each)

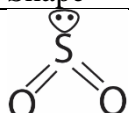
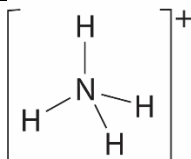
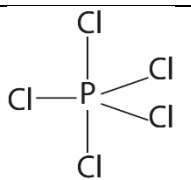


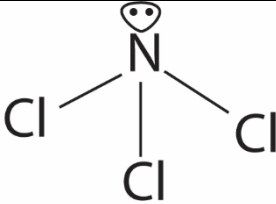


(b) Complete the following equations and in each case write a mechanism for the reaction (@ 1 ½ marks)



4. (a) Sketch and name the shape of each of the following species (4 marks)

Species	Shape	Name of shape
SO_2		V-shape
NH_4^+		tetrahedral
PCl_5		Triangular bipyramdal

NCl ₃		Trigonal pyramidal
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(b) The atomic number of element X is 26.

- (i) Write the outermost electron configuration of x (½ mark)
 $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
- (ii) State the possible oxidation states X can show (1 ½ marks)
 +2 and +3

5. (a) Define what is meant by the term partition coefficient (1 mark)

Partition coefficient is the ratio of solute concentrations in two immiscible liquids at equilibrium.

(b) 100 cm³ of aqueous solution contained 50g of S. Calculate the mass of S that remained in the aqueous layer when the solution was shaken with
 (i) 100 cm³ of solvent A (1 ½ marks)

Let the mass that remain in water be x
 Mass extracted = 50 – x

$$K_D = \frac{\frac{50-x}{100}}{\frac{x}{100}} = \frac{10}{1}$$

$$x = 4.5 \text{ g}$$

Therefore, the mass that remained in water = 4.5g

(ii) Twice with 50 cm³ of solvent A (The partition coefficient of S between A and water is 10:1) (2 ½ marks)

let the mass that remain in aqueous solution after the first extraction be y

$$K_D = \frac{\frac{50-y}{50}}{\frac{y}{100}} = \frac{10}{1} = 8.3\text{g}$$

Let the mass that remained in aqueous solution after the second extraction be =k

$$K_D = \frac{\frac{8.3-k}{50}}{\frac{k}{100}} = \frac{10}{1}$$

$$k = 1.4$$

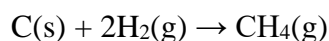
The mass of S that remained in aqueous solution after two extraction = 1.4

- (c) Comment on your results in b (i) and (ii) (1 mark)
 More solute is extracted when the extracting solvent is divided into portions

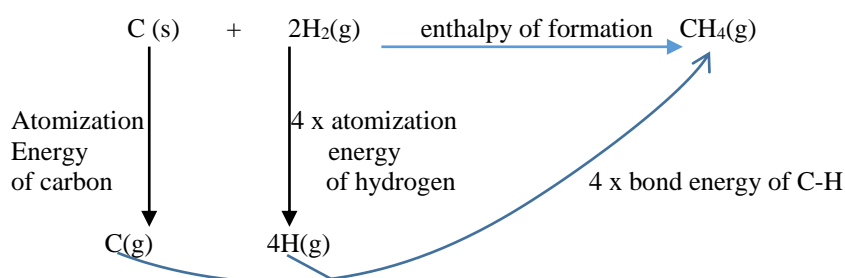
6. (a) What is meant by
 (i) atomisation energy (2 marks)
 atomization energy is energy required to form 1 mole of gaseous atoms from an element at 298K and 1 atmosphere.
 (ii) bond energy
 Bond energy is energy required to break 1 mole of covalent bond in gaseous form

- (b) Carbon reacts with hydrogen

- (i) Write an equation for the reaction



- (ii) Draw a labelled Born Haber cycle and identify the energy changes involved at each step when carbon react with hydrogen (1 mark)



- (c) Given the enthalpy of formation of methane and atomisation energy of carbon and hydrogen are -75 KJmol^{-1} , 715 KJmol^{-1} and 436 KJmol^{-1} respectively, calculate the bond energy for C – H bond (2 marks)
 $-75 = 715 + 436 \times 4 + 4\text{C-H}$

$$\text{C-H bond energy} = 633.5 \text{ kJmol}^{-1}$$

7. (a) A mixture of water and Bromobenzene when steam distilled at standard pressure boils at 95.7°C whereas the b.p of water and Bromobenzene at standard pressure is 100°C and 155°C respectively. Explain why the mixture boils at 95.7°C (2marks)

Water and bromobenzene are immiscible they evaporate independently contributing vapor pressure higher either individual component. This leads to lower boiling point than that of either component.

- (b) Calculate the percentage by mass of Bromobenzene in the distillate from the mixture in (a). (The saturated vapour pressure of water at 95.7°C is 655mmHg).

Molecular mass of bromobenzene ($\text{C}_6\text{H}_5\text{Br}$) = 157

Vapour pressure of bromobenzene = $760 - 655 = 105$

Let the percentage of bromobenzene = x

$$\frac{x}{100-x} = \frac{105 \times 157}{655 \times 18}$$

$$x = 58.3\%$$

Percentage of bromobenzene = 58.3

Percentage of water = 41.7

8. (a) Why does the vapour pressure of a given mass of solvent decrease when a known mass of non-volatile solute is added to the solvent?

A non-volatile solute particle occupies part of the surface of the solvent and reduces the escaping tendency of solvent molecules into vapour.

(b) A solution was prepared by dissolving 7.5g of propan-1,2,3-triol (glycerol), $C_3H_8O_3$ in 200g of water at 25°C and at standard pressure. Calculate the boiling point of the solution at standard pressure (K_b of water = $0.52 \text{ K kg mol}^{-1}$) (3 marks)

Formula mass of $C_3H_8O_3 = 92$

Mass of propan-1,2,3-triol in 1000g of water

200g of water contain 7.5g

$$1000\text{g of water contain } \frac{1000 \times 7.5}{200} = 37.5\text{g}$$

Boiling point elevation

92g cause elevation of 0.52°C

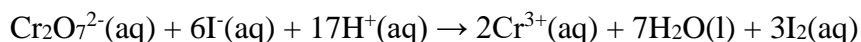
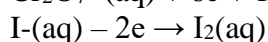
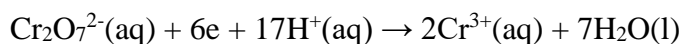
$$37.5\text{g cause elevation of } \frac{0.52 \times 37.5}{92} = 0.2^\circ\text{C}$$

$$\text{Boiling point of solution} = 100 + 0.2 = 100.2^\circ\text{C}$$

9. (a) Acidified potassium dichromate was reacted with potassium iodide
(i) State what was observed (1 mark)

Orange solution turns brown

- (ii) Write the half ionic equation and overall equation for the reaction (2 marks)



SECTION B: (54 MARKS)

10. (a) What is meant by (@ 1 ½ marks)

(i) first ionisation energy

First ionization energy is the minimum energy required to remove the most weakly bound electron from gaseous atom to form gaseous ion with single positive charge.

(ii) electron affinity

Electron affinity is energy change when 1 mole of electron is added to 1 mole of gaseous atom or anions.

(b) The first ionisation energies and first electron affinities of group (VII) elements are given in the table below.

Name of element	First ionisation energy/kJmol ⁻¹	First electron affinity/kJmol ⁻¹
Fluorine	1681	– 328
Chlorine	1250	– 349
Bromine	1139	– 325
Iodine	1007	– 295

(i) State how the first electron affinities of group (VII) elements generally vary with their first ionisation energies (1 mark)

First electron affinity decrease as first ionization energies increase.

(ii) Explain the trend in first electron affinity of group (VII) elements (3 marks)

First electron affinity decrease down the group due to decrease in electronegativity

(c) The boiling point of group (VII) elements increases down the group. Explain this observation (2 marks)

Boiling points increase down the group due to increase in molecular mass that increases the van der Waal forces.

11. (a) Write an expression for the

(i) acid dissociation constant, K_a , for ethanoic acid (2 marks)

$$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$

(ii) relationship between acid dissociation K_a and the degree of ionisation of an acid (1 mark)

$$K_a = \alpha^2 C$$

(b) The molar conductivity at infinite dilution of ethanoic acid at 20°C is $3.5 \times 10^{-2} \text{ Sm}^2 \text{ mol}^{-1}$ while a 1.6×10^{-2} molar conductivity of ethanoic acid at 20°C is $1.225 \times 10^{-3} \text{ Sm}^2 \text{ mol}^{-1}$. Calculate

(i) The degree of ionisation of the acid at 20°C (1 mark)

$$\alpha = \frac{1.225 \times 10^{-3}}{3.5 \times 10^{-2}} = 0.035$$

(ii) The pH of the acid (3 marks)
 $H^+ = \alpha C = 0.035 \times 1.6 \times 10^{-2} = 5.6 \times 10^{-4} \text{ mol dm}^{-3}$
 $pH = -\log H^+ = 3.25$

(c) Besides concentration, state one other factor that can affect the pH of the acid (1 mark)

Temperature

12. State what would be observed and write equations for the reactions that take place when the following compounds are reacted

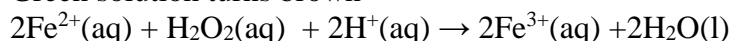
(a) Aqueous iron (III) chloride with sodium carbonate (3 marks)

Brown precipitate and effervescence



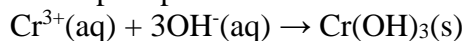
(b) Iron (II) ions and hydrogen peroxide in acidic conditions. (3 marks)

Green solution turns brown

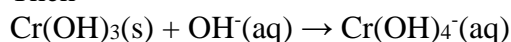


(c) Chromium (III) sulphate with sodium hydroxide dropwise until in excess (3 marks)

Green precipitate formed soluble in excess

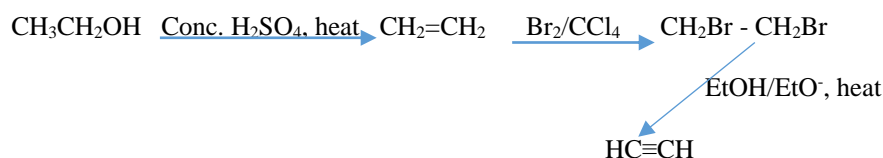


Then

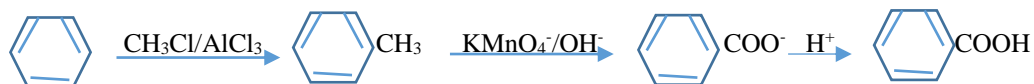


13. Write equations to show how the following conversions can be made

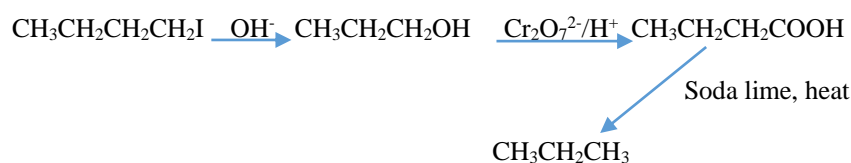
(a) ethyne from ethanol (4 marks)



(b) Benzoic acid from benzene (2 marks)

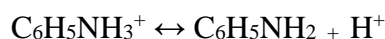


(c) Propane from 1 bromobutane (3 marks)



14. (a) Phenylamine hydrochloride $\text{C}_6\text{H}_5\text{NH}_3^+\text{Cl}^-$ undergoes hydrolysis when dissolved in water. Write an

(i) equation for the reaction (2 mark)



(ii) expression for the hydrolysis constant K_h (1 mark)

$$K_h = \frac{[\text{C}_6\text{H}_5\text{NH}_2][\text{H}^+]}{[\text{C}_6\text{H}_5\text{NH}_3^+]}$$

- (b) A 0.2 molar solution of phenylamine hydrochloride has a pH = 3.5, calculate:

(i) the concentration of hydrogen ions in solution (3 marks)

$$\text{H}^+ = 10^{-3.5} = 3.2 \times 10^{-4} \text{ mol dm}^{-3}$$

(ii) the hydrolysis constant, K_h of phenylamine hydrochloride (3 marks)

$$K_h = \frac{(3.2 \times 10^{-4})^2}{0.2} = 5.12 \times 10^{-7} \text{ mol dm}^{-3}$$

15. The table below gives some data on substances A to D

Substance	A	B	C	D
Melting point ($^{\circ}\text{C}$)	1610	-183	2015	98
Conduction of electricity in molten state	Does not	Does not	Does	Does

- (a) Classify the solid formed by each substance according to its structure and type of bonding

Substance	A	B	C	D
Type of structure	Solid	Molecular	Ionic	metal
Type of bonding	Covalent	Covalent	Ionic	metallic

- (b) In the series Na, Mg, Al, Si, P, S and Cl
State element with

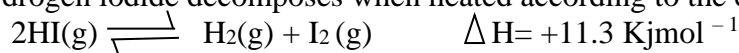
	Element
(i) highest melting point	Si
(ii) Smallest atomic radius	Cl
(iii) largest ionisation energy	Cl
(iv) smallest electronegativity	Na

(2 marks)

- (c) Explain why the element you have stated in (b) (i) has the highest melting point
(3 marks)

Each silicon atom is bonded to 4 silicon atoms by strong covalent bonds to form 3-D structure. These bonds required high temperature to break

16. Hydrogen iodide decomposes when heated according to the equation



- (a) Write an expression for the equilibrium constant K_c for the reaction (½ mark)

$$K_c = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2}$$

- (c) 1.54g of hydrogen iodide was heated in a 600cm³ bulb at 530°C. When equilibrium was attained, the bulb was cooled to room temperature and broken under potassium iodide solution. The iodine formed from the decomposition required 67.0cm³ of 0.1M sodium thiosulphate solution for complete reaction. Calculate

- (i) the number of moles of hydrogen iodide in 1.54g (1 mark)

$$\text{RFM of HI} = 127 + 1 = 128$$

$$\text{Moles} = \frac{1.54}{128} = 0.012$$

- (ii) the number of moles of iodine formed when hydrogen iodide was decomposed (3 ½ marks)

$$\text{Moles of sodium thiosulphate} = \frac{67 \times 0.1}{1000} = 0.0067 \text{ moles}$$

$$\text{Moles of sodium thiosulphate} = 0.0067/2 = 0.00335 \text{ moles}$$

- (iii) the value of K_c at 530°C. (2 ½ marks)

$$\text{Moles H}_2 = 0.00335 \text{ moles}$$

$$\text{Moles of reacted HI} = 0.00335 \text{ moles} \times 2 = 0.0067 \text{ moles}$$

$$\text{Moles of unreacted HI} = 0.012 - 0.0067 = 0.0053$$

$$K_c = \frac{0.00335^2}{0.0053^2} = 0.4$$

- (c) State what would be the effect on the value of K_c if

- (i) the temperature was raised from 530°C to 800°C (1 mark)

K_c increases because the reaction is exothermic

- (ii) the volume of the bulb was increased to 1200 cm³ (1 mark)

K_c remain unchanged.

17. In the extraction of iron, haematite is mixed with coke and limestone and then heated in a blast furnace.

- (a) State the purpose of adding

(i) coke (2 marks)

to produce carbon monoxide that reduces Fe_2O_3 (ore)

(ii) limestone (2 marks)
produces CaO that forms slag with impurities

(b) Explain why iron can be extracted by the method described above (2 mark)

Fe_2O_3 can be reduced by carbon monoxide

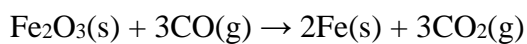
(c) (i) Name one other method that could be used to extract iron from its ore (1 mark)

By electrolysis

(ii) Suggest a reason why the method you have named in c (i) is not commonly used in the production of iron (1 mark)

It is expensive

(d) Write any one equation that illustrates the reduction of the ore in the blast furnace. (2 marks)



END