

P525/2

CHEMISTRY

PAPER 2

2 Hours

UGANDA ADVANCED CERTIFICATE OF EDUCATION

TOPICAL EXAMINATION 2024

TOPIC: THERMOCHEMISTRY

2 Hours

INSTRUCTIONS TO CANDIDATES:

Answer all questions in this paper

Begin each question on a fresh page

1. (a) (i) Define the term enthalpy of solution. (01 mark)
- (ii) State the energy terms that determine the magnitude and sign of the enthalpy of solution of an ionic salt. (02 marks)
- (iii) Describe an experiment that can be used to determine the enthalpy of solution of an ionic salt. (09 marks)

Your answers should include treatment of results and any assumptions used in the experiment. (Diagram is not required.)

(b) Some thermo-chemical data of copper, copper(II) chloride and chlorine are given below.

Enthalpy of formation of $\text{CuCl}_2 = -220 \text{ kJmol}^{-1}$

Enthalpy of sublimation of Cu $= +338.3 \text{ kJmol}^{-1}$

First ionization energy of Cu $= +745 \text{ kJmol}^{-1}$

Second ionization energy of Cu $= +1958 \text{ kJmol}^{-1}$

First electron affinity of chlorine $= -364.0 \text{ kJmol}^{-1}$

Bond dissociation energy of chlorine $= +121.1 \text{ kJmol}^{-1}$

(i) Draw an energy level diagram which can be used to determine the lattice energy of copper(II) chloride.
(04 marks)

(ii) The hydration energy of copper(II) chloride is $-2883.9 \text{ kJmol}^{-1}$. Determine the enthalpy of solution of copper(II) chloride.
(03 marks)

(iii) Comment on the solubility of copper(II) chloride.
(01 mark)

2.(a) Define the term enthalpy of hydration (01 mark)

(b) In an experiment to determine the enthalpy of hydration of anhydrous copper(II) sulphate by indirect method, 4.0g of the anhydrous salt was added to 50.0g of water and the temperature of water rose by 8.0°C . When 4.0g of the hydrated salt was added to 50.0g of water, the water temperature dropped by 0.9°C .

[Specific heat capacity of solution $= 4.2 \text{ Jg}^{-1} \text{ K}^{-1}$; Cu = 64; S = 32; O = 16; H = 1]

Calculate the enthalpy of solution of

(i) anhydrous copper(II) sulphate, (03 marks)

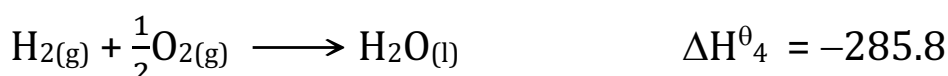
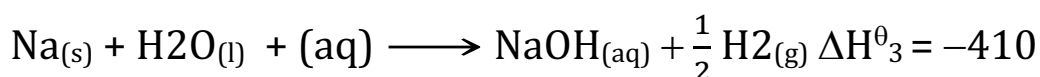
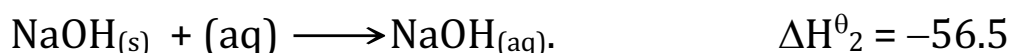
(ii) hydrated copper(II) sulphate–5–water. (03 marks)

(c) (i) State which one of the copper salts in (b) is more soluble in water and explain your answer. (03 marks)

(ii) Determine the enthalpy of hydration of anhydrous copper(II) sulphate. (02 marks)

(d) The enthalpies of some reactions are given below.

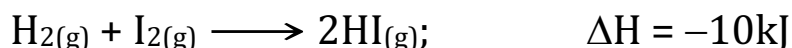
$$\Delta H^\circ_f / \text{kJ mol}^{-1}$$



(i) Calculate the standard enthalpy of formation of sodium oxide from its elements. (04 marks)

(ii) From your answer in (d) (i), state whether sodium oxide is a stable compound or not. Give a reason for your answer. (1 marks)

(e) Hydrogen reacts with Iodine according to the following equation:



(i) Draw a labelled diagram for potential energy versus reaction coordinate for the reaction (2 ½ marks)

(ii) The rate of the reaction is given by $\text{Rate} = K[\text{H}_2][\text{I}]$. Determine the overall order of the reaction. (½ marks).

3. (a) (i) What is meant by the term standard enthalpy of combustion? (01 mark)

(ii) Describe an experiment that can be carried out to determine the enthalpy of combustion of liquid cyclohexane. (Diagram **not** required) (05 marks)

(b) The standard enthalpies of combustion of the first five straight chain alkanes are shown in the table below.

Number of carbon atoms (n)	0	1	2	3	4	5
Enthalpy of combustion of alkanes, $-\Delta H^\circ_c$ (kJmol ⁻¹)	286	890	1560	2220	2877	3509

(i) Plot a graph of the enthalpies of combustion of alkanes against number of carbon atoms. (03 marks)

(ii) Use the graph to determine the enthalpy of combustion of hexane. (02 marks)

(iii) Explain the shape of the graph. (04 marks)

(c) The enthalpies of combustion of some substances are given in the table below:

Substance	Hydrogen	Benzene	Cyclohexene	Cyclohexane
Standard enthalpy of combustion, ΔH^θ (kJmol ⁻¹)	-285	-3280	-3725	-3920

(i) Calculate the enthalpy of hydrogenation of cyclohexene and benzene. (03 marks)

(ii) Comment on your answer in (c)(i) (02 marks)

4. (a) What do you understand by the term bond energy?
(01 mark)

(b) State and explain three factors affecting average bond energies.
(09 marks)

(c) The average bond energies for group(VII) elements are given in the table below.

Bond	Bond energy/ kJmol^{-1}
F-F	+158
Cl-Cl	+242
Br-Br	+193
I-I	+151

State and explain the trend in the bond energies for the halogens.
(03 marks)

(d) Given the following enthalpy changes below,

Enthalpy of atomisation of Carbon = $+715\text{kJmol}^{-1}$

Enthalpy of formation of methane = -75kJmol^{-1}

Enthalpy of atomisation of hydrogen = $+218\text{kJmol}^{-1}$

Determine the average C-H bond energy. (03 marks)

(e) (i) Define the term lattice energy. (01 mark)

(ii) Explain two factors that affect the magnitude of lattice energy. (03 marks)

END