

Born-Haber Cycles

Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Chemical Energetics
Sub-Topic	Born-Haber Cycles
Paper Type	Theory
Booklet	Question Paper 3

Time Allowed: 56 minutes

Score: /46

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 Magnesium will react on heating with chlorine, or oxygen, or nitrogen to give the chloride, or oxide, or nitride respectively. Each of these compounds is ionic and in them magnesium has the same +2 oxidation state.

(a) (i) Write an equation, with state symbols, for the **second** ionisation energy of magnesium.

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(ii) Use the *Data Booklet* to calculate the enthalpy change that occurs when one mole of gaseous magnesium ions, Mg^{2+} , is formed from one mole of gaseous magnesium atoms.

Include a sign in your answer.

enthalpy change = kJ mol^{-1}
[3]

(b) Separate samples of magnesium chloride and magnesium oxide are shaken with water. In **each** case, describe what you would see when this is done, and state the approximate pH of the water after the solid has been shaken with it.

(i) magnesium chloride

observation

approximate pH of the water

(ii) magnesium oxide

observation

approximate pH of the water

[4]

- (c) Magnesium burns in nitrogen to give magnesium nitride, a yellow solid which has the formula Mg_3N_2 .

Magnesium nitride reacts with water to give ammonia and magnesium hydroxide.

- (i) Construct an equation for the reaction of magnesium nitride with water.

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- (ii) Does a redox reaction occur when magnesium nitride reacts with water?

Use the oxidation numbers of nitrogen to explain your answer.

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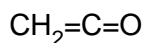
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[4]

[Total: 11]

- 2 Ketene, C_2H_2O , is a member of a class of unsaturated organic compounds that is widely used in pharmaceutical research for the synthesis of organic compounds.



ketene

- (a) (i) Suggest values for the H-C-H and C=C=O bond angles in ketene.

H-C-H C=C=O

- (ii) By considering the structure of the molecule, suggest why the name *ketene* is used.

.....
..... [3]

- (b) Ketene burns completely in air to form carbon dioxide and water.

- (i) Write a balanced equation for this reaction.

.....

- (ii) Use your equation to calculate the volume of CO_2 , in dm^3 , measured at room temperature and pressure, which will be formed when 3.5 g of ketene are burned in an excess of air.

Give your answer to **two** significant figures.

volume of CO_2 = dm^3 [4]

- (c) (i) Define the term *standard enthalpy change of formation*.

.....

.....

.....

- (ii) Use the data below to calculate the standard enthalpy change of formation of ketene.

	$\Delta H^\ominus/\text{kJ mol}^{-1}$
standard enthalpy change of formation of CO_2	-395
standard enthalpy change of combustion of H_2	-286
standard enthalpy change of combustion of $\text{CH}_2=\text{C}=\text{O}$	-1028

[6]

- (d) Ketene can be converted directly into ethanoic acid, $\text{CH}_3\text{CO}_2\text{H}$, by reaction with a compound **A**.

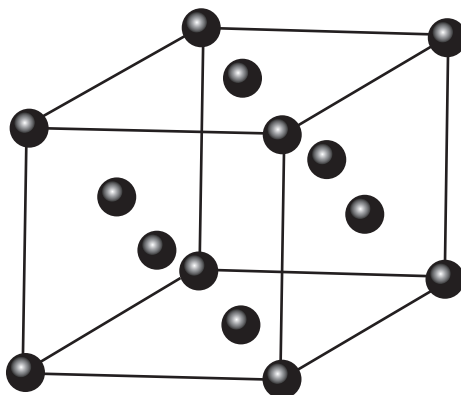
Suggest the identity of **A**.

.....

[1]

[Total: 14]

- 3 Copper and iodine are both solids which have different physical and chemical properties. Each element has the same face-centred crystal structure which is shown below.



The particles present in such a crystal may be atoms, molecules, anions or cations. In the diagram above, the particles present are represented by ●.

- (a) Which type of particles are present in the iodine crystal? Give their formula.

particle

formula

[2]

- (b) When separate samples of copper or iodine are heated to 50°C, the copper remains as a solid while the iodine turns into a vapour.

- (i) Explain, in terms of the forces present in the solid structure, why copper remains a solid at 50°C.

.....
.....
.....

- (ii) Explain, in terms of the forces present in the solid structure, why iodine turns into a vapour when heated to 50°C.

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.....
.....

[4]

- (c) (i)** Although copper is a relatively unreactive metal, when it is heated to a high temperature in an excess of chlorine, copper(II) chloride is formed.

How does chlorine behave in this reaction?

.....

- (ii)** When a mixture of copper and iodine is heated to a high temperature, no reaction occurs.

Suggest a reason for this difference.

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[2]

[Total: 8]

4 Carbon disulphide, CS_2 , is a volatile, stinking liquid which is used to manufacture viscose rayon and cellophane.

(a) The carbon atom is in the centre of the CS_2 molecule.

Draw a 'dot-and-cross' diagram of the carbon disulphide molecule.

Show outer electrons only.

[2]

(b) Suggest the shape of the molecule and give its bond angle.

shape

bond angle

[2]

(c) Explain the term *standard enthalpy change of formation*, ΔH_f^\ominus .

.....
.....
..... [3]

(d) Calculate the standard enthalpy change of formation of CS_2 from the following data.

standard enthalpy change of formation of SO_2 = -298 kJ mol^{-1}

standard enthalpy change of formation of CO_2 = -395 kJ mol^{-1}

standard enthalpy change of combustion of CS_2 = $-1110 \text{ kJ mol}^{-1}$

[3]

- (e) Carbon disulphide reacts with nitrogen monoxide, NO, to form a yellow solid and two colourless gases which are produced in a 1:1 molar ratio.

Deduce the identity of **each** gas and write a balanced equation for the reaction.

gases and

equation [3]

[Total: 13]