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CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	Oxidation Reducation & Redox
PAPER TYPE:	QUESTION PAPER - 2
TOTAL QUESTIONS	10
TOTAL MARKS	47

Oxidation, Reduction and Redox Equations - 2

1. Vanadium is an important metal.
Ferrovanadium, an alloy of iron and vanadium, is used to make a strong type of vanadium-steel.
Pure vanadium is used in nuclear reactors.

(a) The table shows some standard enthalpy of formation data.

	$V_2O_5(s)$	$CaO(s)$
ΔH_f^θ / kJ mol^{-1}	−1560	−635

In the oldest method of extraction of vanadium, V_2O_5 is reacted with calcium at a high temperature.

$5Ca(s) + V_2O_5(s) \rightarrow 2V(s) + 5CaO(s)$

Use data from the table and the equation to calculate the standard enthalpy change for this reaction.
State the type of reaction that V_2O_5 has undergone.
Suggest one major reason why this method of extracting vanadium is expensive, other than the cost of heating the reaction mixture.

(5)

(b) Ferrovanadium is produced by the reaction of aluminium with a mixture of V_2O_5 and iron(III) oxide.

Write an equation for the reaction of aluminium with iron(III) oxide.

State the change in oxidation state of aluminium in this reaction.

(2)

(c) Pure vanadium, for nuclear reactors, is formed by the reaction of hydrogen with purified VCl_2

Write an equation for this reaction in which the only other product is HCl gas.

Identify two hazards in this process, other than the fact that it operates at a high temperature.

Deduce why this process produces pure vanadium, other than the fact that purified VCl_2 is used.

(4)

2. Which equation does not represent a redox reaction?

A. $Mg + 2HCl \rightarrow MgCl_2 + H_2$
B. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
C. $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
D. $CuO + 2HCl \rightarrow CuCl_2 + H_2O$

(Total 1 mark)

3. The silicon chip industry requires the production of pure silicon.
Silicon is extracted from its ore, silicon dioxide (SiO_2), by a process similar to that used in the extraction of titanium.

(a)

i. Write an equation for the formation of $SiCl_4$ from SiO_2 using chlorine and carbon.

(1)

ii. Suggest how the liquid $SiCl_4$ is purified.

(1)

(b) The final stage in the extraction of silicon involves the use of hydrogen gas to convert the $SiCl_4$ into silicon and hydrogen chloride.

i. Write an equation for this reaction.

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(1)

ii. State the role of hydrogen in this reaction.

(1)

iii. Give one risk associated with the use of hydrogen gas.

(1)

(c) The magnesium used to make magnesium ferrosilicon alloys is extracted from magnesium oxide using silicon.
Write an equation for this reaction to produce magnesium and silicon dioxide.

(1)

4. V_2O_5 can be used as a catalyst in the Contact Process.
Which is a step in the Contact Process in which the vanadium is oxidised?

A. $SO_2 + V_2O_5 \longrightarrow SO_3 + 2VO_2$
B. $SO_3 + 2VO_2 \longrightarrow SO_2 + V_2O_5$
C. $2VO_2 + \frac{1}{2}O_2 \longrightarrow V_2O_5$
D. $V_2O_5 \longrightarrow 2VO_2 + \frac{1}{2}O_2$

(Total 1 mark)

5. A sample of nitrogen dioxide gas (NO_2) was prepared by the reaction of copper with concentrated nitric acid.

(a)

i. Balance the equation for the reaction of copper with concentrated nitric acid.

Cu + ... $HNO_3 \rightarrow Cu(NO_3)_2$ + ... NO_2 + ... H_2O

(1)

ii. Give the oxidation state of nitrogen in each of the following compounds.

HNO_3

NO_2

(2)

iii. Deduce the half-equation for the conversion of HNO_3 into NO_2 in this reaction.

(1)

(b) The following equilibrium is established between colourless dinitrogen tetraoxide gas (N_2O_4) and dark brown nitrogen dioxide gas.

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $\Delta H = 58 \text{ kJ mol}^{-1}$

i. Give two features of a reaction at equilibrium.

(2)

ii. Use Le Chatelier's principle to explain why the mixture of gases becomes darker in colour when the mixture is heated at constant pressure.

(2)

iii. Use Le Chatelier's principle to explain why the amount of NO_2 decreases when the pressure is increased at constant temperature.

(2)

6. Which of these is a redox reaction?

A. $CaO + SiO_2 \longrightarrow CaSiO_3$

B. $H2SO_4 + Na_2O \longrightarrow Na_2SO_4 + H_2O$
C. $NaBr + H_2SO_4 \longrightarrow NaHSO_4 + HBr$
D. $Mg + S \longrightarrow MgS$

(Total 1 mark)

7. Metals are usually extracted from oxides. Some of these oxides occur naturally. Other oxides are made by roasting sulfide ores in air, producing sulfur dioxide as a by-product.

(a) For the extraction of some metals, the oxide needs to be converted into a chloride.
The ore molybdenite contains molybdenum disulfide (MoS_2).
The first stage in the extraction of molybdenum is to roast the ore in air to form molybdenum oxide (MoO_3) and sulfur dioxide.

i. Write an equation for the first stage in this extraction.

(1)

ii. The release of sulfur dioxide into the atmosphere causes environmental problems and wastes a valuable resource.
Identify one environmental problem and identify one use for the sulfur dioxide.

(2)

iii. Pure molybdenum is formed in the second stage by the reduction of MoO_3 using hydrogen.
Write an equation for this reaction.

(1)

iv. State one risk in using hydrogen gas in metal extractions.

(1)

(b) Calcium is an expensive metal. It is extracted by the electrolysis of molten calcium chloride.

i. State why calcium chloride must be molten for electrolysis to occur.

(1)

ii. Write an equation for the reaction that takes place at the negative electrode during this electrolysis.

(1)

iii. Identify the major cost in this extraction of calcium.

(1)

8. Which of these species is the best reducing agent?

A. Cl_2
B. Cl^-
C. I_2
D. I^-

(Total 1 mark)

9. Refer to the unbalanced equation below when answering this question.

$K_2Cr_2O_7 + 3H_2C_2O_4 + \_H_2SO_4 \rightarrow Cr_2(SO_4)_3 + \_H_2O + 6CO_2 + K_2SO_4$

What is the reducing agent in this reaction?

A. H^+
B. $C_2O_4^{2-}$

C. K^+
D. $Cr_2O_7^{2-}$

(Total 1 mark)

10. Copper is extracted from the ore chalcopyrite ($CuFeS_2$) in a three-stage process.

(a) In the first stage of this extraction, the chalcopyrite is heated with silicon dioxide and oxygen.

i. Balance the following equation for this first stage in which copper(I) sulfide is formed.

.....$CuFeS_2$ + ...SiO_2 + ...O_2 → Cu_2S + ...$FeSiO_3$ + ...SO_2

(1)

ii. Give one environmental reason why the SO_2 gas formed in this reaction is not allowed to escape into the atmosphere.

(1)

iii. State one use for the sulfur dioxide formed in this reaction.

(1)

(b) In the second stage of this extraction, the copper(I) sulfide is converted into copper(II) oxide.
This occurs by roasting the sulfide with oxygen at high temperature. Write an equation for this reaction.

(1)

(c) In the third stage of this extraction, copper(II) oxide is reduced to copper by its reaction with carbon.
Write an equation for this reaction.

(1)

(d) Scrap iron can be used to extract copper from dilute aqueous solutions containing copper(II) ions.

i. Explain why this is a low-cost method of extracting copper.

(1)

ii. Write the simplest ionic equation for the reaction of iron with copper(II) ions in aqueous solution.

(1)

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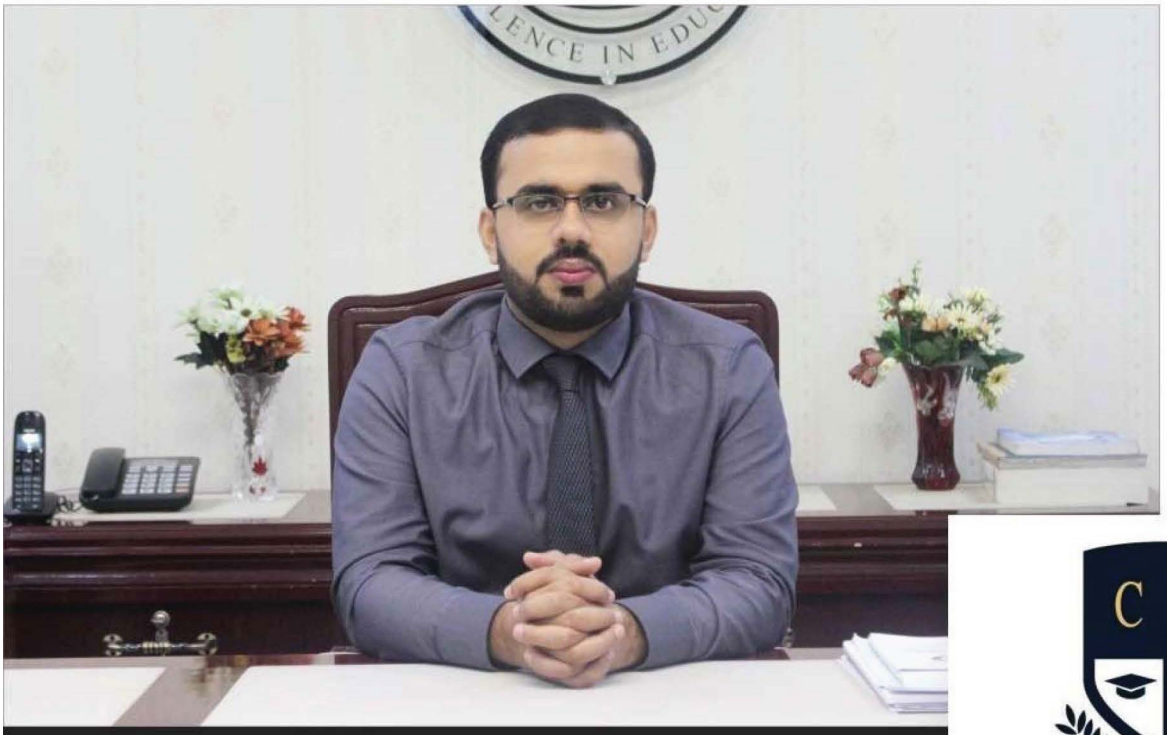

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