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CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	Oxidation Reducation & Redox
PAPER TYPE:	QUESTION PAPER - 4
TOTAL QUESTIONS	10
TOTAL MARKS	48

Oxidation, Reduction and Redox Equations - 4

1. Nitric acid is manufactured from ammonia in a process that involves several stages.

(a) In the first stage, ammonia is converted into nitrogen monoxide and the following equilibrium is established.

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H = -905$ kJ mol^{-1}

The catalyst for this equilibrium reaction is a platinum–rhodium alloy in the form of a gauze.

i. This catalyst gauze is heated initially but then remains hot during the reaction.
In terms of redox, state what happens to the ammonia in the forward reaction.

(1)

ii. Suggest a reason why the catalyst must be hot.

(1)

iii. Suggest a reason why the catalyst remains hot during the reaction.

(1)

iv. State how a catalyst increases the rate of a reaction.

(2)

(b) In the second stage, nitrogen monoxide is converted into nitrogen dioxide.

The equation for the equilibrium that is established is shown below.

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = -113 \text{ kJ mol}^{-1}$

Explain why the equilibrium mixture is cooled during this stage of the process.

(2)

(c) In the final stage, nitrogen dioxide reacts with water as shown by the following equation.

$2NO_2(g) + H_2O(l) \rightarrow H^+(aq) + NO_3^-(aq) + HNO_{2(}aq)$

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

NO_2

NO_3^-

HNO_2

I am Sorry !!!!!

(3)

2. Which of these shows nitrogen in its correct oxidation states in the compounds given?

	NH_3	N_2O	HNO_2
A.	+3	−1	+5
B.	−3	+1	+3
C.	−3	+1	−5
D.	+3	−1	−3

(Total 1 mark)

3. A solution of iron(II) sulfate was prepared by dissolving 10.00 g of $FeSO_4.7H_2O$ (Mr = 277.9) in water and making up to 250 cm^3 of solution.

The solution was left to stand, exposed to air, and some of the iron(II) ions became oxidised to iron(III) ions.

A 25.0 cm^3 sample of the partially oxidised solution required 23.70 cm^3 of 0.0100 mol dm^{-3} potassium dichromate(VI) solution for complete reaction in the presence of an excess of dilute sulfuric acid.

Calculate the percentage of iron(II) ions that had been oxidised by the air.

(6)

4. Which one of the following is the electron arrangement of the strongest reducing agent?

A. $1s^2\ 2s^2\ 2p^5$
B. $1s^2\ 2s^2\ 2p^6\ 3s^2$
C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
D. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

(Total 1 mark)

5. In the past 150 years, three different processes have been used to extract bromine from potassium bromide.
These processes are illustrated below.

Extraction Process 1

$2KBr + MnO_2 + 2H_2SO_4 \rightarrow MnSO_4 + K_2SO_4 + 2H_2O + Br_2$

Extraction Process 2

The reaction of solid potassium bromide with concentrated sulfuric acid.

Extraction Process 3

The reaction of aqueous potassium bromide with chlorine gas.

(a) Write a half-equation for the conversion of MnO_2 in acid solution into Mn^{2+} ions and water.

In terms of electrons, state what is meant by the term oxidising agent and identify the oxidising agent in the overall reaction.

(3)

(b) Write an equation for Extraction Process 2 and an equation for Extraction Process 3.

Calculate the percentage atom economy for the extraction of bromine from potassium bromide by Extraction Process 3.

Suggest why Extraction Process 3 is the method in large-scale use today.

(5)

(c) Bromine has been used for more than 70 years to treat the water in swimming pools.

The following equilibrium is established when bromine is added to water.

$Br_2 + H_2O \rightleftharpoons HBrO + HBr$

Give the oxidation state of bromine in HBr and in HBrO

Deduce what will happen to this equilibrium as the HBrO reacts with micro-organisms in the swimming pool water.

Explain your answer.

(4)

6. Which one of the following contains the metal with the lowest oxidation state?

A. CrO_2F_2
B. $[Cr_2O_7]^2$
C. $[MnCl_6]^{2-}$
D. $[Mn(CN)_6]^{3-}$

(Total 1 mark)

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

(a) Balance the equation for the reaction of copper with concentrated nitric acid.

Cu + ... HNO_3 → $Cu(NO_3)_2$ + ... NO_2 + ... H_2O

(1)

(b) Give the oxidation state of nitrogen in each of the following compounds.

HNO_3

NO_2

(2)

(c) Deduce the half-equation for the conversion of HNO_3 into NO_2 in this reaction.

(1)

8. Which one of the following is not a redox reaction?

A. $TiO_2 + 2Cl_2 + C \rightarrow TiCl_4 + CO_2$
B. $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$
C. $MgO + 2HCl \rightarrow MgCl_2 + H2O$
D. $3MnO + 4H^+ \rightarrow 2MnO + MnO_2 + 2H_2O$

(Total 1 mark)

9. Chlorine and bromine are both oxidising agents.

(a) Define an oxidising agent in terms of electrons.

(1)

(b) In aqueous solution, bromine oxidises sulphur dioxide, SO_2, to sulphate ions, SO_4^{2-}

i. Deduce the oxidation state of sulphur in SO_2 and in SO_4^{2-}

(1)

ii. Deduce a half-equation for the reduction of bromine in aqueous solution.

(1)

iii. Deduce a half-equation for the oxidation of SO_2 in aqueous solution forming and H+ ions.

(1)

iv. Use these two half-equations to construct an overall equation for the reaction between aqueous bromine and sulphur dioxide.

(2)

(c) Write an equation for the reaction of chlorine with water.

Below each of the chlorine-containing products in your equation, write the oxidation state of chlorine in that product.

(3)

(d) Give a reason why chlorine is not formed when solid potassium chloride reacts with concentrated sulphuric acid.

(1)

(e) Write an equation for the reaction between solid potassium chloride and concentrated sulphuric acid.

(1)

(f) Solid potassium bromide undergoes a redox reaction with concentrated sulphuric acid.

i. Give the oxidation product formed from potassium bromide.

(1)

ii. Give the reduction product formed from sulphuric acid.

(1)

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

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

In the balanced equation the mole ratio for sulfuric acid to water is

A. 1 : 4
B. 1 : 2
C. 4 : 7
D. 4 : 9

(Total 1 mark)

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