OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY 2816/01

Unifying Concepts in Chemistry

Wednesday **19 JUNE 2002** Afternoon 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry
Scientific calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	11	
2	18	
3	15	
4	16	
TOTAL	60	

This question paper consists of 10 printed pages and 2 blank pages.

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For Examiner's Use

Answer **all** questions.

1 A chemist set up an equilibrium system between dinitrogen tetroxide, N_2O_4, and nitrogen dioxide, NO_2, at 25 °C.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

The equilibrium concentrations were: $N_2O_4(g)$, 0.0390 mol dm^{-3}; $NO_2(g)$, 0.0150 mol dm^{-3}.

(a) (i) Write the expression for K_c in this equilibrium system.

[1]

(ii) Calculate K_c for this equilibrium. State the units.

[2]

(b) The standard enthalpy changes of formation of N_2O_4 and NO_2 are given below.

compound	$\Delta H_f^{\ominus}$/kJ mol^{-1}
N_2O_4	+9
NO_2	+33

Calculate the standard enthalpy change for the forward reaction in this equilibrium.

[2]

(c) This equilibrium system was heated at constant pressure. How would you expect the relative proportions of N_2O_4 and NO_2 to change? Explain your answer.

change .....

explanation .....

.....

.....[3]

(d) NO_2 and N_2O_4 are both poisonous. After this investigation, the chemist needed to dispose of 0.00465 mol N_2O_4 safely. The chemist decided to do this by reacting the N_2O_4 with an alkali and chose aqueous sodium hydroxide.

$$N_2O_4(g) + 2NaOH(aq) \longrightarrow NaNO_3(aq) + NaNO_2(aq) + H_2O(l)$$

Calculate the minimum volume of 0.300 mol dm^{-3} NaOH(aq) required to dispose of this amount of N_2O_4.

[3]

[Total : 11]

2 The reaction between hydrogen, H_2, and nitrogen monoxide, NO, has the following rate equation.

$$\text{rate} = k[H_2(g)][NO(g)]^2$$

(a) Using 6.0×10^{-3} mol dm^{-3} $H_2(g)$ and 3.0×10^{-3} mol dm^{-3} NO(g), the initial rate of this reaction was 4.5×10^{-3} mol dm^{-3} s^{-1}.

Calculate the rate constant, *k*, for this reaction and state its units.

[3]

(b) Predict what would happen to the reaction rate after the following changes in concentrations. Show your reasoning.

(i) The concentration of $H_2(g)$ is doubled.

effect on rate .....

reason .....

.....[2]

(ii) The concentration of NO(g) is halved.

effect on rate .....

reason .....

.....[2]

(iii) The concentrations of $H_2(g)$ and NO(g) are both tripled.

effect on rate .....[1]

(c) The overall equation for the reaction between hydrogen and nitrogen monoxide is shown below.

$$2H_2(g) + 2NO(g) \longrightarrow N_2(g) + 2H_2O(l)$$

This reaction takes place by a two step mechanism with the rate-determining step taking place first.

(i) Explain the term *rate-determining step*.

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.....[1]

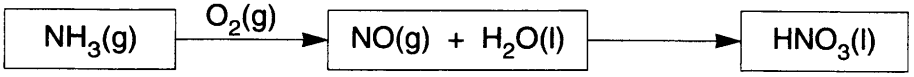
(ii) Suggest the two steps for this reaction and write their equations below. The equation for the rate-determining step (RDS) has been partly completed.

step 1 (RDS) ..... + 2..... $\longrightarrow$ ..... + $H_2O(l)$

step 2 ..... + ... $\longrightarrow$ $N_2(g) + H_2O(l)$

[2]

(d) Each year in the UK, 700 000 tonnes of nitric acid, HNO_3, are manufactured for the production of fertilisers, dyes, explosives, etc. Nitrogen monoxide, NO, is prepared as an intermediate in the production of nitric acid from ammonia, NH_3.



(i) What is the oxidation state of nitrogen in the following?

NH_3 .....

NO .....

HNO_3 .....[3]

(ii) Construct a balanced equation for the formation of NO(g) from $NH_3(g)$.

.....[2]

(iii) Assuming that 1 mol NH_3 produces 1 mol HNO_3, calculate the mass of NH_3 that is required to meet the annual demand for HNO_3 in the UK.

[2]

[Total : 18]

3 Alpha hydroxy acids (AHAs) are monobasic organic acids, used in skin creams to combat the appearance of ageing. Approximately 1% solutions of AHAs remove wrinkles as the low pH aggravates the skin, causing it to swell. More concentrated solutions (approximately 12% or 1.5 mol dm^{-3}) are used to remove dead skin.

(a) An AHA was analysed and had the percentage composition by mass:

C, 40.0%; H, 6.7%; O, 53.3%. $M_r = 90$.

Calculate the molecular formula of this AHA.

[3]

(b) Calculate the pH of a 1.5 mol dm^{-3} solution of an AHA with an acid dissociation constant, K_a, of 1.2 x 10^{-5} mol dm^{-3}. Show your working.

[4]

(c) Beauty treatments often contain buffers. An example of a buffer is a mixture of ethanoic acid, CH_3COOH, and an ethanoate salt such as sodium ethanoate, CH_3COONa.

(i) Explain what is meant by a *buffer solution*.

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.....[1]

(ii) Write the chemical equation for the equilibrium in this buffer system.

.....[1]

(iii) Explain how this buffer solution works. Use equations where appropriate.

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.....[3]

(d) A buffer solution was prepared using equal concentrations of CH_3COOH and CH_3COONa.

What would be the effect on the pH of this buffer solution of adding some solid CH_3COONa? Explain your answer.

effect on pH .....

explanation .....

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.....[3]

[Total : 15]

4 In this question, you should use knowledge, principles and concepts from different areas of chemistry. *(In this question, 1 mark is available for the quality of written communication.)*

(a) The equation for the production of ammonia in the Haber process is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92\,kJ\,mol^{-1}$$

Explain why the conditions of temperature and pressure used in the Haber process (450 °C, 15 000 kPa) are a **compromise**.

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.....[7]

(b) An *Alka-Seltzer* tablet contains about 0.5 g sodium hydrogencarbonate, $NaHCO_3$, and an excess of citric acid. When water is added to an *Alka-Seltzer* tablet, carbon dioxide gas is released.

The equation for the reaction that takes place is shown below. The formula of citric acid has been simplified as H_3A.

$$3NaHCO_3 + H_3A \longrightarrow Na_3A + 3CO_2 + 3H_2O$$

(i) Explain, using ionic equations, how the addition of water allows the release of carbon dioxide from an *Alka-Seltzer* tablet.

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.....[4]

(ii) Calculate the minimum mass of citric acid that needs to be in an *Alka-Seltzer* tablet to ensure that all the sodium hydrogencarbonate reacts. (M_r citric acid: 192)

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.....[5]

[Total : 16]