Equilibria

Question Paper 6

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Equilibria
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 6

Time Allowed: **71 minutes**

Score: **/59**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 Ibuprofen is one of the most commonly used non-steroidal anti-inflammatory drugs, used to treat chronic arthritic pain caused by inflammation of the joints.
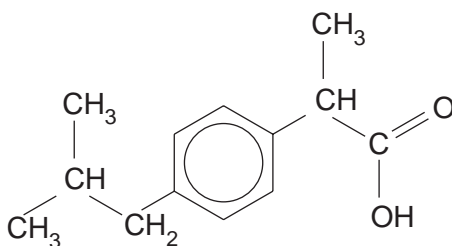
ibuprofen

(a) (i) Draw a circle around any chiral centre(s) in the above structure.

(ii) Write down the molecular formula of ibuprofen.

....

(iii) Calculate the M_r of ibuprofen and use it to calculate how many grams are needed to make $100\,cm^3$ of a $0.15\,mol\,dm^{-3}$ solution.

....

....

....

(iv) Vigorous oxidation of ibuprofen produces a dibasic acid **A**. A solution containing $0.10\,g$ of **A** required $12.0\,cm^3$ of $0.10\,mol\,dm^{-3}$ NaOH for neutralisation.

Suggest a structure for **A**, showing your working.

....

[7]

(b) The K_a value for ibuprofen is $6.3 \times 10^{-6}\,mol\,dm^{-3}$.

(i) Write an expression for K_a.

....

(ii) Use the K_a value to calculate the pH of a $0.15\,mol\,dm^{-3}$ solution of ibuprofen.

....

....

[3]

(c) To avoid problems with digestive irritation over a long period of use, research is being carried out into ways of administering ibuprofen using skin patches. For this use the compound is dissolved in a hydrophilic gel which acts as a buffer.

(i) What do you understand by the term *buffer*?

....

....

The buffer used in the pharmaceutical preparation is a solution containing Na_2HPO_4 and NaH_2PO_4. These salts contain the HPO_4^{2-} and $H_2PO_4^{-}$ ions respectively.

(ii) Write equations to show how this buffer reacts with

H^+ ions, ...

OH^- ions. ....

(iii) A buffer solution containing equal concentrations of the two sodium phosphate salts has a pH of 7.20.

Calculate the pH of a pharmaceutical preparation containing $0.002\,mol\,dm^{-3}$ of Na_2HPO_4 and $0.005\,mol\,dm^{-3}$ of NaH_2PO_4.

[5]

[Total: 15]

2   Sulphur and its compounds are found in volcanoes, in organic matter and in minerals.

Sulphuric acid, an important industrial chemical, is manufactured from sulphur by the Contact process. There are three consecutive reactions in the Contact process which are essential.

(a) Write a balanced equation (using $\rightleftharpoons$ where appropriate) for **each** of these reactions **in the correct sequence**.

1 ....

2 ....

3 .... [4]

(b) What catalyst is used?

.... [1]

Hydrogen sulphide, H_2S, is a foul-smelling compound found in the gases from volcanoes. Hydrogen sulphide is covalent, melting at –85 °C and boiling at –60 °C.

(c)   **(i)** Draw a 'dot-and-cross' diagram to show the structure of the H_2S molecule.

(ii) Predict the shape of the H_2S molecule.

....

(iii) Oxygen and sulphur are both in Group VI of the Periodic Table.

Suggest why the melting and boiling points of water, H_2O, are much higher than those of H_2S.

....

....

.... [4]

Hydrogen sulphide burns with a blue flame in an excess of oxygen to form sulphur dioxide and water.

(d) **(i)** Write a balanced equation for the complete combustion of H_2S.

....

(ii) What is the change in the oxidation number of sulphur in this reaction?

from .... to ....

(iii) What volume of oxygen, measured at room temperature and pressure, is required for the complete combustion of 8.65 g of H_2S? Give your answer to two decimal places.

[5]

Hydrogen sulphide is a weak diprotic (dibasic) acid. Its solution in water contains HS^- and a few S^{2-} ions.

(e) **(i)** What is meant by the term *weak acid*?

....

....

(ii) Write an equation, with state symbols, for the **first** ionisation of H_2S when it dissolves in water.

.... [3]

[Total: 17]

3 **(a)** Give an expression for K_a as applied to the weak acid RCO_2H.

....

.... [1]

(b) The K_a values for three carboxylic acids are listed in the table below.

acid	K_a / mol dm^{-3}
CH_3CO_2H	1.8×10^{-5}
$ClCH_2CO_2H$	1.4×10^{-3}
Cl_2CHCO_2H	5.5×10^{-2}

(i) Describe and explain the trend in acid strength illustrated by these values.

....

....

....

....

(ii) Calculate the pH of a 0.100 mol dm^{-3} solution of $ClCH_2CO_2H$.

....

....

....

(iii) Calculate the pK_a value for Cl_2CHCO_2H.

....

....

[5]

(c) The acid $ClCH_2CO_2H$ features in the industrial synthesis of the important weedkiller 2,4-D.
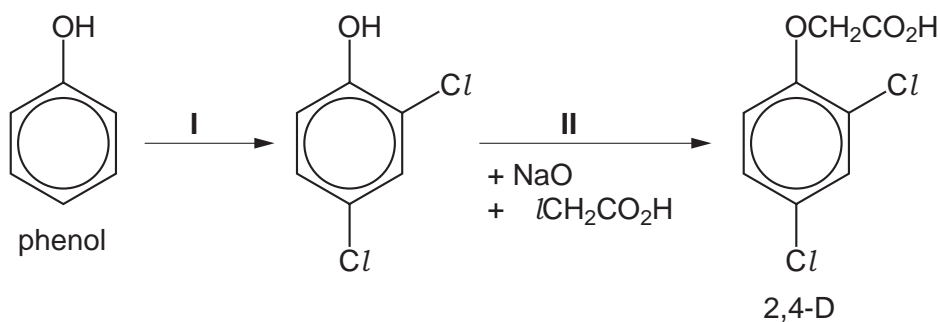
  (i) Suggest a possible reagent for reaction **I**.

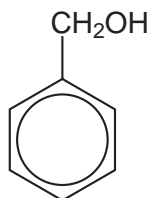...

 (ii) What type of reaction is

reaction **I**, ...

reaction **II**? ....

(iii) Describe a test (reagents and observations) that would distinguish phenol from compound **A**.

compound **A**

reagents ....

observation with phenol ....

observation with compound **A** ....

[5]

[Total: 11]

4 Ammonia, NH_3, is a colourless, pungent-smelling gas which has been known to man from the beginning of recorded time. It is given off from urine such as that on a wet nappy from a baby.

The nitrogen-containing substance in urine is urea, $CO(NH_2)_2$, and this decomposes by hydrolysis into ammonia and another colourless gas.

(a) Construct an equation for the hydrolysis of aqueous urea.

....[2]

Ammonia was named after the shrine of Jupiter Ammon which was near the Egyptian-Libyan border. In ancient times ammonia was obtained by distilling camel dung.

(b) Now ammonia is synthesised from its elements in the Haber Process.

(i) Write an equation for this process.

....

(ii) State the **three** usual operating conditions of the Haber Process.

....

....

....

(iii) State **two** modern commercial uses of ammonia.

....

....[4]

(c) $1.20\,dm^3$ of ammonia gas were dissolved in water to form $200\,cm^3$ of aqueous alkali at room temperature and pressure.

(i) Use the *Data Booklet* to calculate how many moles of $NH_3(g)$ were dissolved.

(ii) Write the equation for the neutralisation of aqueous ammonia by dilute sulphuric acid.

....

(iii) Calculate the volume of $0.50\,mol\,dm^{-3}$ sulphuric acid that is required to neutralise the $200\,cm^3$ of aqueous ammonia.
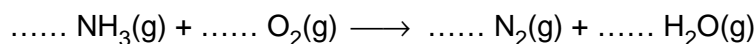
[3]

(d) In the boxes below, draw diagrams to show the shapes of an ammonia molecule and an ammonium ion. Clearly show the bond angles on your diagrams.

ammonia	ammonium ion

[4]

(e) Ammonia does not burn in air but will burn in pure oxygen.

(i) Balance the equation for this reaction:

...... $NH_3(g)$ + ... $O_2(g) \longrightarrow$ ...... $N_2(g)$ + ... $H_2O(g)$

(ii) Use oxidation numbers to explain why this is a redox reaction.

....

....

....[3]

[Total : 16]