OCR
Oxford Cambridge and RSA

A Level Chemistry B (Salters)

H433/02 Scientific literacy in chemistry

Practice paper – Set 1

Time allowed: 2 hours 15 minutes

You must have:
- the Advanced Notice
- the Data Sheet for Chemistry B (Salters)

You may use:
- a scientific calculator

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **20** pages.

Answer **all** questions.

1 PVC and nylon make two types of film that are used to wrap food.

(a) PVC is used as a cling-wrap. It is made by polymerising 'vinyl chloride', $CH_2{=}CHCl$.

(i) Give the systematic name for 'vinyl chloride'.

.... **[1]**

(ii) Give the **skeletal** formulae of **two** possible products that vinyl chloride forms when reacted with hydrogen bromide.

Write your formulae in the boxes below.

[1]

(iii) A student has a sample of gaseous vinyl chloride.

Describe a chemical test that would indicate the presence of vinyl chloride.

....

....

.... **[1]**

(b) **(i)** Draw the **full** structural formula of the repeating unit of PVC.

[1]

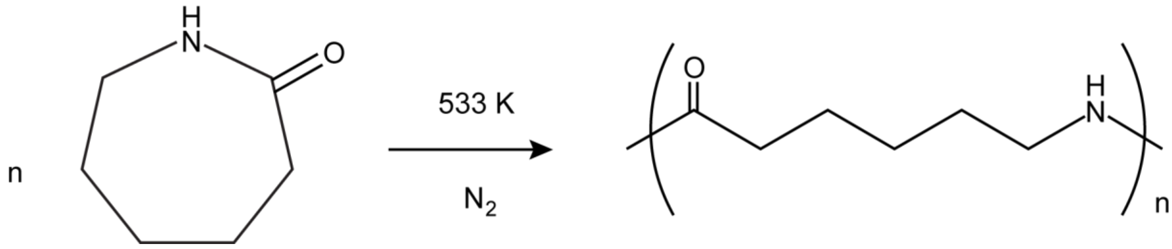
(ii) The use of PVC as a cling-wrap depends on its intermolecular bonds.

Name the strongest type of intermolecular bond between PVC chains.

.... **[1]**

(c) Nylon-6 is also used to wrap food.

Nylon-6 is formed by polymerising 'caprolactam'.



caprolactam **nylon-6**

(i) Name the functional group in caprolactam.

.... **[1]**

(ii) Give the meaning of the '6' in nylon-6.

....

.... **[1]**

(iii) Explain why the reaction of caprolactam to nylon-6 is **not** condensation and suggest how the reaction is classified.

....

.... **[2]**

(iv) Nylon-6 can be used at much higher temperatures than PVC without softening.

Suggest a reason for this in terms of intermolecular bonds.

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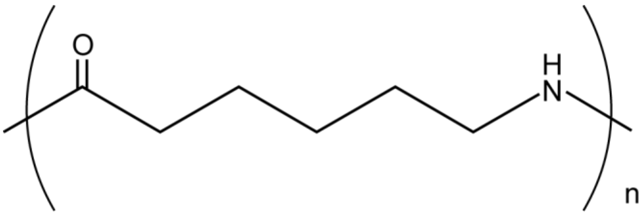
.... **[4]**



Nylon-6

(d) Some students carry out acid hydrolysis on a sample of nylon-6.

(i) Suggest the reagent and conditions they use.

reagent: ....

conditions: ....
[2]

(ii) The students obtain a product, compound **A**, that is not cyclic.

Compound **A** is formed by the acid hydrolysis of nylon-6.

Give the formula of compound **A**.

[1]

(iii) Compound **A** will not polymerise to nylon-6.
Compound **A** can be neutralised and then changed to compound **B**.
Compound **B will** polymerise at room temperature to form nylon-6.

Give the structure of compound **B** and name the new functional group it contains.

Compound **B**

Name of functional group: ....**[2]**

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2 Scientists involved in the conservation of old leather books are concerned about the presence of acidic ammonium sulfate rotting the surface of the leather.
The ammonium sulfate is formed by sulfuric acid from polluted air reacting with proteins in the leather.

(a) Proteins contain $CONH_2$ groups.

Complete and balance the equation below to show the reaction of this group with aqueous sulfuric acid to form ammonium sulfate and an organic product.

$$RCONH_2 \ + \ \ H_2SO_4 \ + \ \ H_2O \ \rightarrow$$

[2]

(b) The following equilibrium exists in an aqueous solution of ammonium ions.

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

(i) On the equation above indicate an acid-base pair, labelling which is the acid and which the base.

[1]

(ii) Write the expression for K_a for the ammonium ion.

K_a =

[1]

(iii) The pH of a 0.10 mol dm^{-3} solution of ammonium ions is 5.13.

Calculate the value of K_a for the ammonium ion and give its units.

K_a = ... units...................................... **[3]**

(iv) Ammonia is a weak base and it has an 'ionisation constant', K_b, given by the following expression.

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

Use the expressions for K_a, K_b and K_w to calculate a value for K_b.

K_b = ...mol dm^{-3} **[2]**

(c) A buffer solution based on 'lactic acid' is sometimes used to buffer the acidic effects of the ammonium sulfate.
Lactic acid is a weak acid with $K_a = 1.38 \times 10^{-4}$ mol dm^{-3}.

(i) A student sets out to make a buffer solution using lactic acid and its sodium salt.

Calculate the mass of salt (M_r = 112) that must be dissolved in
250 cm^3 of 0.0100 mol dm^{-3} lactic acid (M_r = 90) to produce a buffer of pH 4.0.

mass of salt = ...g **[3]**

(ii) A student says that the salt must be added as a solid and not as a solution of the salt, otherwise the pH of the buffer will not be exactly 4.0.

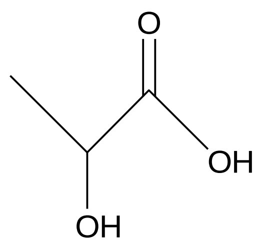
Comment on this statement.

....

....

.... **[1]**

(d) The skeletal structure of lactic acid is shown below.



lactic acid

When dried with concentrated sulfuric acid, lactic acid forms a cyclic ester with molecular formula $C_6H_8O_4$.

Suggest how the cyclic ester is formed from lactic acid.

Give the structure of the cyclic ester.

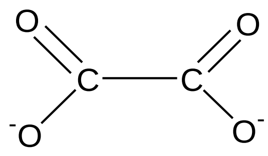
....

....

.... **[2]**

3 *Bar Keeper's Friend* is a powdered cleaning agent invented over 100 years ago and still in use today. It is particularly effective at removing rust stains.

The active ingredients are the ethanedioate ion, shown below, and ethanedioic acid.



Ethanedioate ion

A student decides to investigate how *Bar Keeper's Friend* removes rust stains. The student finds that the ethanedioate ions act as bidentate ligands which form complexes with Fe^{3+} ions.

(a) (i) On the diagram above show how this bidentate ligand bonds to a Fe^{3+} ion.
On the diagram, name the type of bond formed. **[3]**

(ii) The complex ion formed between the ethanedioate ligands, $C_2O_4^{2-}$, and Fe^{3+} has a charge of 3–.

Give the formula and name the shape of the complex.

formula:..

name of shape: .... **[2]**

(b) The student also investigates whether ethanedioic acid $(COOH)_2$ undergoes a redox reaction with Fe^{3+} ions.

Half-reaction	$E^{\ominus}$/V
$2CO_2 + 2H^+ + 2e^- \rightleftharpoons (COOH)_2$	–0.43
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77

(i) Use data from the table to explain why $(COOH)_2$ and Fe^{3+} ions react.

....

....

....

.... **[2]**

(ii) Write an ionic equation for the reaction between $(COOH)_2$ and Fe^{3+} in solution.

[2]

(iii) Draw arrows in the appropriate boxes to show the outer electron configurations for Fe^{2+} and Fe^{3+}.

	3d						4s
Fe^{2+}							
Fe^{3+}							

[2]

(c) Ethanedioate ions react with manganate(VII) ions as shown below.

$$5C_2O_4^{2-} + 2MnO_4^{-} + 16H^{+} \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O \qquad \textbf{equation 3.1}$$

(i) Complete the tables below to show the oxidation states of manganese and carbon in the reagents and products.

Mn	MnO_4^{-}	Mn^{2+}
oxidation states		

C	$C_2O_4^{2-}$	CO_2
oxidation states		

[2]

(ii) Explain how the oxidation states can be used to balance the equation.

....

....

....

.... **[1]**

$$5C_2O_4^{2-} + 2MnO_4^{-} + 16H^{+} \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O \quad \textbf{equation 3.1}$$

(d) The reaction above can be used to find the concentration of an ethanedioate solution.

The ethanedioate solution is titrated with a standard potassium manganate(VII) solution in acid conditions.
The reaction is slow at room temperature and needs to be heated above 60 °C.

(i)* Describe how the titration would be carried out and explain how the end-point of the reaction can be recognised without an indicator.

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.... **[6]**

$$5C_2O_4^{2-} + 2MnO_4^{-} + 16H^{+} \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$$ **equation 3.1**

(ii) A student makes up 0.100 dm^3 of a $K_2C_2O_4{\bullet}H_2O$ solution.
The student finds that 25.0 cm^3 of this solution react with 18.40 cm^3 of 0.0500 mol dm^{-3} $KMnO_4$ solution.

Calculate the mass of $K_2C_2O_4{\bullet}H_2O$ used to make up the solution.

Give your answer to an **appropriate** number of significant figures.

mass of $K_2C_2O_4{\bullet}H_2O$ = ...g **[5]**

(e) Ethanedioic acid can be made by oxidising 'ethylene glycol', $HOCH_2CH_2OH$.

(i) Give the systematic name of ethylene glycol.

.... **[1]**

(ii) Ethylene glycol has two primary alcohol groups.

Explain the meaning of the term *primary alcohol.*

....

.... **[1]**

(f) Ethylene glycol can be oxidised under different conditions from the ones used in **(e)**.
The compound 'glyoxal' is produced.
Glyoxal has two functional groups that are the same.

(i) Name the functional group.

.... **[1]**

(ii) Describe a chemical test for this group, not involving acid dichromate.
Give the positive result of the test.

....

....

....

.... **[2]**

4 Research is being conducted into chemical reactions that can be used on other planets such as Mars.

One reaction being studied is shown below.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g) \quad \Delta_r H = +40 \text{ kJ mol}^{-1} \qquad \textbf{equation 4.1}$$

The atmosphere of Mars consists mainly of carbon dioxide.
Hydrogen is initially brought from Earth.

(a) Suggest, with reasons, what effect increasing temperature and pressure would have on the **equilibrium yield** of carbon monoxide and water in **equation 4.1**.

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.... **[4]**

(b) A catalyst of iron and chromium is used.

State why the catalyst is used and give its effect on K_c.

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.... **[2]**

$$H_2(g) \; + \; CO_2(g) \; \rightleftharpoons \; H_2O(g) + CO(g) \quad \Delta_r H = +40 \text{ kJ mol}^{-1}$$ **equation 4.1**

(c) At 500 K the equilibrium constant for **equation 4.1** is 7.76×10^{-3}.
A mixture containing the **initial** concentrations shown below is allowed to reach equilibrium at 500 K.

$[H_2(g)]_{init} = 1.16 \times 10^{-5}$ mol dm^{-3}

$[CO_2(g)]_{init} = 1.16 \times 10^{-5}$ mol dm^{-3}

Calculate the equilibrium concentration of $H_2O(g)$ in the mixture.

equilibrium concentration of $H_2O(g)$ = ...mol dm^{-3} **[4]**

(d) The water is electrolysed to regenerate the hydrogen.

(i) Energy is needed to electrolyse water.

Suggest a source of energy that is available on Mars.

....

....**[1]**

(ii) Suggest a reason why the electrolysis of water is beneficial to sustaining life on Mars.

....

....**[1]**

$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$ $\Delta_r H = +40$ kJ mol^{-1} **equation 4.1**

(e) The value of $\Delta_{sys}S$ for the forward reaction in **equation 4.1** is +42 J mol^{-1} K^{-1}.

Gas	**Entropy, *S*/ J mol^{-1} K^{-1}**
CO	+198
CO_2	+214
H_2O	+189

Use the data above to calculate the entropy of $H_2(g)$.

entropy of $H_2(g)$ = ...J mol^{-1} K^{-1} **[1]**

(f) **(i)** Calculate the value of $\Delta_{tot}S$ for the forward reaction in **equation 4.1** at 1000°C.

$\Delta_{tot}S$ = ...J mol^{-1} K^{-1} **[2]**

(ii) Explain what you can deduce about the forward reaction in **equation 4.1** at 1000°C.

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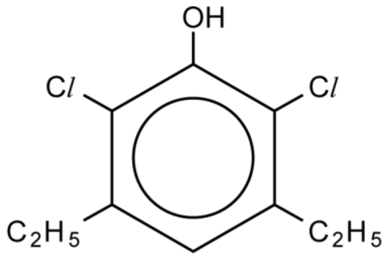
....**[2]**

5 This question refers to the Advance Notice Article *Dettol* which accompanies this paper.

(a) A chemist suggests using compound **C**, shown below, as an ingredient in an antiseptic such as dettol.



Compound C

(i) Give the systematic name of compound **C**.

.... **[1]**

(ii) Suggest, with a reason, **one** way in which compound **C** might be a better ingredient in dettol than the compound PCMX.

....

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.... **[1]**

(iii) Suggest, with reasons, **two** ways in which compound **C** might be a worse ingredient in dettol than the compound PCMX.

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.... **[2]**

(b) Explain why compounds with an aromatic ring usually form substituted derivatives, rather than addition compounds.

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.... **[2]**

(c) Suggest how PCMX binds to proteins.

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.... **[1]**

(d) PCMX is slightly more acidic than phenol. Suggest why this is so.

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.... **[2]**

(e) PCMX can dissolve in water and in non-polar solvents.

Name the intermolecular forces broken in the solvent in each case.

water ....

non-polar solvents .... **[2]**

(f) The solubility of PCMX (M_r = 156.6) is 330 mg dm^{-3}
and its K_a is 1.99 × 10^{-10} mol dm^{-3}.

Calculate the pH of a saturated solution of PCMX.

pH = ... **[3]**

(g)* Explain what is meant by a *soap* and how a soap makes PCMX more soluble in water.

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.... **[6]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).