

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

INTERNATIONAL AS CHEMISTRY (9620)

Unit 2: Organic 1 and Physical 1

Wednesday 23 May 2018 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



Answer **all** questions in the spaces provided.

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outside the
box

0 1

Isomers of octane are hydrocarbons used in motor fuels.

0 1 . 1

Name the process used to obtain kerosene from crude oil.

[1 mark]

Fractional distillation

0 1 . 2

Octane can be produced by catalytic cracking of kerosene.

Identify the catalyst and state the temperature used in this process.

Write an equation to show the cracking of one molecule of pentadecane ($C_{15}H_{32}$) to form octane and one other product.

Use molecular formulas in your equation.

[3 marks]

Catalyst *Zeolite (aluminosilicate)*

Temperature *750 K (about 480 °C)*

Equation

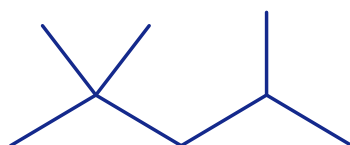


0 1 . 3

2,2,4-trimethylpentane is an isomer of octane used in motor fuels.

Draw the skeletal formula of 2,2,4-trimethylpentane.

[1 mark]

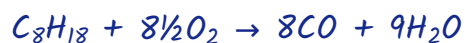


0 1 . 4

Write an equation to show the incomplete combustion of 2,2,4-trimethylpentane to form carbon monoxide and water only.

Use molecular formulas in your equation.

[1 mark]



0 1 . 5

Carbon monoxide is removed using a catalytic converter.

Write an equation to show how the carbon monoxide reacts to form less harmful products in the catalytic converter.

[1 mark]



0 1 . 6

Explain how a catalyst works.

[2 marks]

A catalyst provides an alternative reaction pathway (route)

which has a lower activation energy, so more collisions have energy

greater than or equal to E_a and the rate increases.

Turn over for the next question

Turn over ►



0 2

Difluoromethane (CH_2F_2) and trifluoromethane (CHF_3) are used as refrigerants.

0 2 . 1

Fluorine can react with difluoromethane to form trifluoromethane.

Give **one** essential condition for this reaction and name the mechanism.

[2 marks]

Condition UV light

Name of mechanism Free-radical substitution

0 2 . 2

Write an equation for each of the following steps in the mechanism for this reaction.

[4 marks]

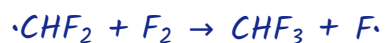
Initiation step



First propagation step



Second propagation step



A termination step



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0 3

This question is about reactions of halogenoalkanes.

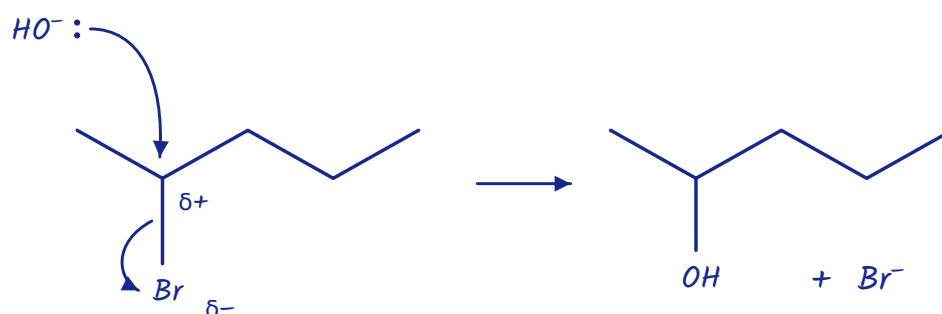
0 3 . 1

2-Bromopentane reacts with aqueous sodium hydroxide to form pentan-2-ol.

Name and outline the mechanism for this reaction.

[3 marks]Name of mechanism Nucleophilic substitution

Mechanism



0 3 . 2

Other halogenoalkanes also react with aqueous sodium hydroxide to form pentan-2-ol.

Identify a halogenoalkane that reacts at a faster rate than 2-bromopentane to form pentan-2-ol.

Explain your answer.

[2 marks]Halogenoalkane 2-iodopentane, $\text{CH}_3\text{CHICH}_2\text{CH}_2\text{CH}_3$

Explanation The C-I bond is weaker than the C-Br bond (lower bond enthalpy), so the C-I bond breaks more easily and the reaction is faster.



0 3 . 3

A mixture of three alkenes can be formed when 2-bromopentane reacts with hot, ethanolic sodium hydroxide. Two of these alkenes are a pair of stereoisomers.

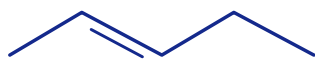
State what is meant by the term stereoisomers.

Draw the skeletal formulas of the two stereoisomers formed in this reaction.

[3 marks]

Stereoisomers have the same structural formula but a different arrangement of the atoms (bonds) in space.

Isomer 1

*(E)-pent-2-ene*

Isomer 2

*(Z)-pent-2-ene*

0 3 . 4

Identify an isomer of 2-bromopentane that does **not** react with hot, ethanolic sodium hydroxide to produce an alkene.

[1 mark]

1-bromo-2,2-dimethylpropane, $(\text{CH}_3)_3\text{CCH}_2\text{Br}$



0	4
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Hydrated ethanedioic acid has the formula $\text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O}$

A student completed an experiment to determine the value of x in the formula.

0	4	.	1
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The student made up a solution of ethanedioic acid in a volumetric flask as follows

- 2.00 g of solid hydrated ethanedioic acid were placed in a weighing bottle.
- The solid acid was transferred to a beaker and dissolved in some distilled water.
- The solution formed was then transferred to a clean 250 cm^3 volumetric flask through a funnel.
- The beaker and funnel were washed and the washings were transferred to the volumetric flask.
- Distilled water was added up to the 250 cm^3 mark.

Give **two** improvements to the student's method.

[2 marks]

Improvement 1 *Reweigh the weighing bottle after transferring the solid to the beaker, to find the exact mass of acid used (or rinse the weighing bottle into the beaker).*

Improvement 2 *Stopper the volumetric flask and invert it several times so the solution is thoroughly mixed.*

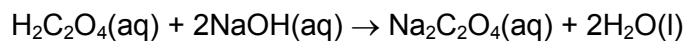


0 4 . 2

25.0 cm³ of the solution of ethanedioic acid were titrated with a 0.115 mol dm⁻³ sodium hydroxide solution.

Aqueous sodium hydroxide solution was added from a burette and 27.35 cm³ were needed for neutralisation.

Ethanedioic acid reacts with sodium hydroxide as follows



Calculate the value of x in H₂C₂O₄·xH₂O

You **must** show your working.

[5 marks]

$$n(\text{NaOH}) = 27.35 \times 0.115 \div 1000 = 3.145 \times 10^{-3} \text{ mol}$$

$$n(\text{H}_2\text{C}_2\text{O}_4) \text{ in } 25.0 \text{ cm}^3 = 3.145 \times 10^{-3} \div 2 = 1.573 \times 10^{-3} \text{ mol}$$

$$n(\text{H}_2\text{C}_2\text{O}_4) \text{ in } 250 \text{ cm}^3 = 1.573 \times 10^{-3} \times 10 = 1.573 \times 10^{-2} \text{ mol}$$

$$M_r \text{ of } \text{H}_2\text{C}_2\text{O}_4 \cdot x\text{H}_2\text{O} = 2.00 \div 1.573 \times 10^{-2} = 127.2$$

$$M_r(\text{H}_2\text{C}_2\text{O}_4) = 90.0, \text{ so mass of water} = 127.2 - 90.0 = 37.2$$

$$x = 37.2 \div 18.0 = 2.07 \approx 2$$

$$x \quad \underline{2 \quad (2.07)}$$

Question 4 continues on the next page

Turn over ►



0 4 . 3

State why it is important to fill the space below the tap in the burette before beginning an accurate titration.

[1 mark]

Otherwise this space fills with NaOH solution during the titration, so the recorded titre would be too high (more than the volume that reacted).

0 4 . 4

State why the funnel used to fill the burette should be removed before starting the titration.

[1 mark]

Drops of solution left in the funnel could fall into the burette during the titration, making the recorded titre lower than the true value.

0 4 . 5

State why rinsing the inside of the conical flask with distilled water during a titration can improve the accuracy of the end point.

[1 mark]

It washes reagent splashed on the sides of the flask back into the reaction mixture, so that all of the acid and alkali react.

0 4 . 6

The total percentage uncertainty in the titre is $\pm 0.15 \text{ cm}^3$

Calculate the total percentage uncertainty in the titre value in this experiment.

[1 mark]

$$(0.15 \div 27.35) \times 100 = 0.548 \%$$

Percentage 0.55 %

11

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0 5

Compounds with carbon–carbon double bonds are useful as they take part in a wide variety of reactions.

0 5 . 1

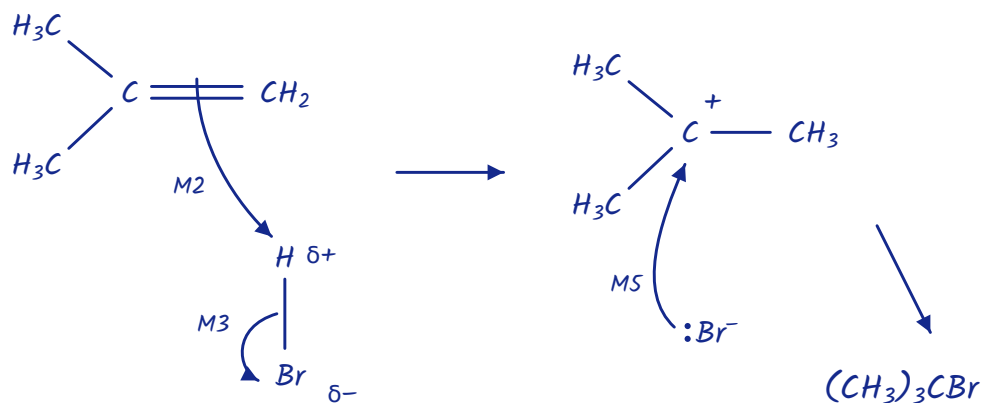
2-Methylpropene reacts with hydrogen bromide to form 2-bromo-2-methylpropane.

Name and outline the mechanism to show the formation of 2-bromo-2-methylpropane from 2-methylpropene.

[5 marks]

Name of mechanism Electrophilic addition

Mechanism

**0 5 . 2**

In the reaction in Question **05.1**, small amounts of 1-bromo-2-methylpropane are also formed.

Explain why 2-bromo-2-methylpropane is the major product.

[2 marks]

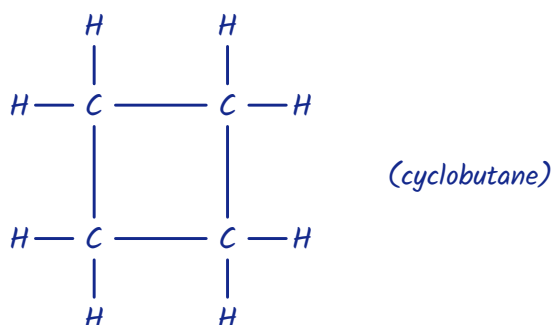
2-bromo-2-methylpropane is formed via a tertiary carbocation, which is more stable than the primary carbocation.

Its three alkyl groups release electron density towards the positive carbon (positive inductive effect).



0 5 . 3 Draw the displayed formula of a functional group isomer of 2-methylpropene.

[1 mark]



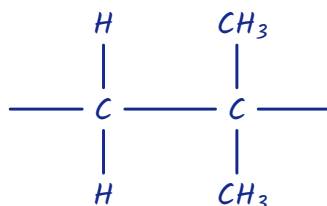
0 5 . 4 2-Methylpropene forms a polymer that is used in chewing gum.

Give the repeating unit of the polymer formed from 2-methylpropene.

State the IUPAC name of the polymer.

[2 marks]

Repeating unit



Name of polymer poly(2-methylpropene)

0 5 . 5 Explain why the polymer in chewing gum is unreactive.

[2 marks]

The polymer is saturated: it contains only strong, non-polar C-C and C-H bonds.

So it is not attacked by nucleophiles or electrophiles and cannot be hydrolysed (it is unreactive towards enzymes).



0 6

Four tests were used to identify the unknown organic compounds **A**, **B**, **C** and **D**.
The observations from these tests are shown in **Table 1**.

Table 1

	Test 1	Test 2	Test 3	Test 4
	Addition of bromine water	Addition of acidified potassium dichromate(VI)	Addition of Tollens' reagent	Addition of sodium carbonate
A	remains orange	turns green	silver mirror formed	no visible change
B	remains orange	turns green	no visible change	no visible change
C	remains orange	remains orange	no visible change	effervescence
D	turns colourless	turns green	no visible change	no visible change

0 6 . 1

Use the observations from **Table 1** to identify the unknown organic compound that **must** contain two different functional groups.

[1 mark]

Tick (✓) **one** box.

A

☐

B

☐

C

☐

D

☒

0 6 . 2

Identify the gas formed in the reaction of compound **C** with sodium carbonate in **Test 4**.

[1 mark]

Carbon dioxide, CO₂

0 6 . 3

In the reaction of acidified potassium dichromate(VI) in **Test 2**, green Cr³⁺ ions are formed.

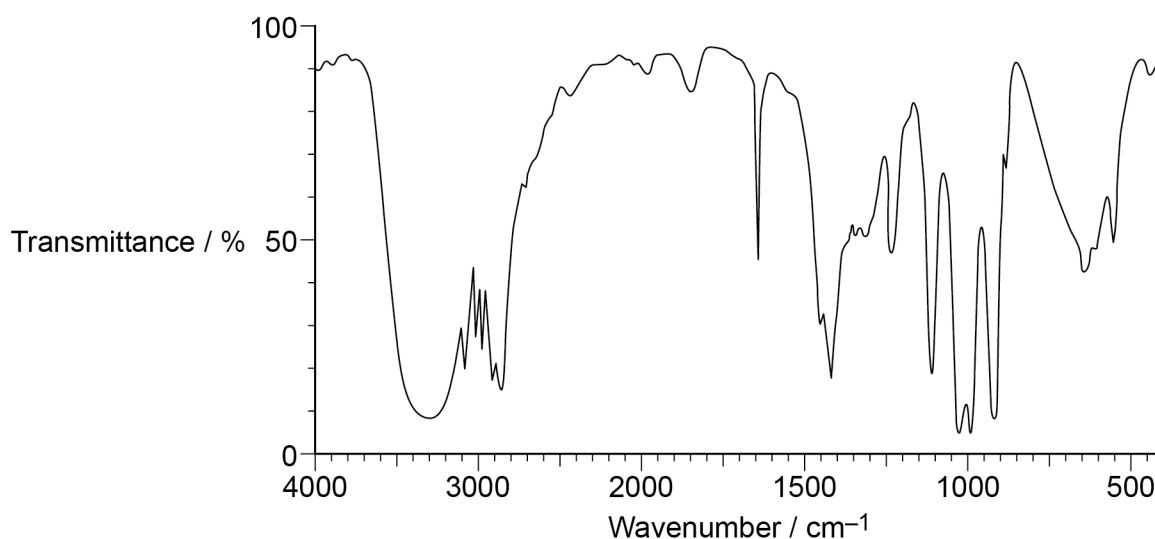
Write a half-equation to show the conversion of Cr₂O₇²⁻ ions into Cr³⁺ ions.

[1 mark]



The infrared spectrum of compound **B** is shown in **Figure 1**.

Figure 1



0 6 . 4

Use the infrared spectrum to deduce which one of the tests for compound **B** shown in **Table 1** is incorrect.

Explain your answer.

[3 marks]

Test Test 1 (bromine water)

Explanation The spectrum has a sharp absorption at about 1650 cm^{-1} (range $1620\text{ to }1680\text{ cm}^{-1}$), due to a $\text{C}=\text{C}$ bond.

So B contains a $\text{C}=\text{C}$ bond and would decolourise bromine water (orange to colourless) rather than remain orange.

6

Turn over for the next question

Turn over ►



0 7

Alcohols undergo combustion, oxidation and elimination reactions.

0 7 . 1

An unknown alcohol is analysed by complete combustion.

When 0.250 g of the alcohol is burned, 0.625 g of carbon dioxide and 0.307 g of water are produced.

Calculate the empirical formula of the alcohol.

[5 marks]

$$n(\text{CO}_2) = 0.625 \div 44.0 = 0.01420 \text{ mol}$$

$$\text{mass C} = 0.01420 \times 12.0 = 0.1705 \text{ g}$$

$$n(\text{H}_2\text{O}) = 0.307 \div 18.0 = 0.01706 \text{ mol}$$

$$\text{mass H} = 0.01706 \times 2 \times 1.0 = 0.0341 \text{ g}$$

$$\text{mass O} = 0.250 - 0.1705 - 0.0341 = 0.0454 \text{ g}$$

$$\text{C} : \text{H} : \text{O}$$

$$0.1705 \div 12.0 : 0.0341 \div 1.0 : 0.0454 \div 16.0$$

$$= 0.01420 : 0.0341 : 2.84 \times 10^{-3}$$

$$\div 2.84 \times 10^{-3} = 5.00 : 12.0 : 1$$

$$\text{Empirical formula} = \text{C}_5\text{H}_{12}\text{O}$$

Empirical formula C₅H₁₂O



- 0 7 . 2** Butan-1-ol can be oxidised to butanoic acid in a two-step process.



The reaction mixture is heated under reflux to make sure that the oxidation to butanoic acid is complete.

Write an overall equation for the oxidation of butan-1-ol to form butanoic acid.

Use [O] in your equation to represent the oxidising agent.

[1 mark]



- 0 7 . 3** Explain how heating under reflux ensures the complete oxidation of butan-1-ol to butanoic acid.

[2 marks]

Any butan-1-ol or butanal that evaporates is condensed in the vertical condenser and returns to the flask as a liquid.

So unreacted butan-1-ol and butanal stay in the mixture with the oxidising agent and can be oxidised further to butanoic acid.

- 0 7 . 4** Explain why butanal has a lower boiling point than both butan-1-ol and butanoic acid.

[3 marks]

Butanal has no O-H group, so there are only permanent dipole-dipole forces (and van der Waals forces) between butanal molecules.

Butan-1-ol and butanoic acid both have an O-H group, so they form hydrogen bonds between their molecules.

Dipole-dipole forces are weaker than hydrogen bonds, so less energy is needed to overcome them.

Question 7 continues on the next page

Turn over ►



0 7 . 5 Identify the isomer of butan-1-ol that is **not** easily oxidised.

[1 mark]

2-methylpropan-2-ol, $(\text{CH}_3)_3\text{COH}$

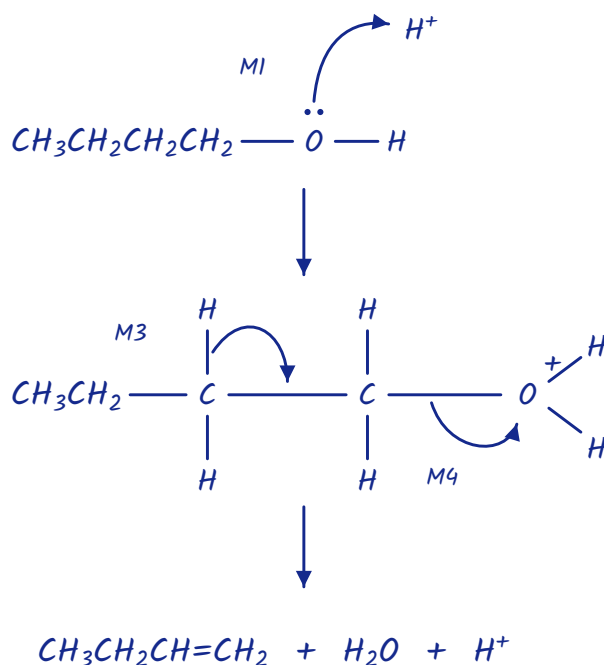
0 7 . 6 Butan-1-ol can be converted into but-1-ene in an elimination reaction.

Give the reagent used and outline the mechanism for this reaction.

[5 marks]

Reagent Concentrated H_2SO_4 (or concentrated H_3PO_4)

Mechanism



END OF QUESTIONS



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