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Centre number 

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# OXFORD AQA INTERNATIONAL AS CHEMISTRY (9620)

Unit 2 Organic 1 and Physical 1

Monday 22 January 2018 06:00 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                  |      |
| <b>TOTAL</b>       |      |



J A N 1 8 C H O 2 0 1

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

0 1

Alkenes react with electrophiles.

0 1 . 1

State what is meant by the term **electrophile**.

[1 mark]

*An electron pair acceptor.*

0 1 . 2

Bromine is a non-polar molecule.

Explain why alkenes undergo electrophilic addition reactions with bromine.

[2 marks]

*C=C is an area of high electron density (electron-rich  $\pi$  bond).*

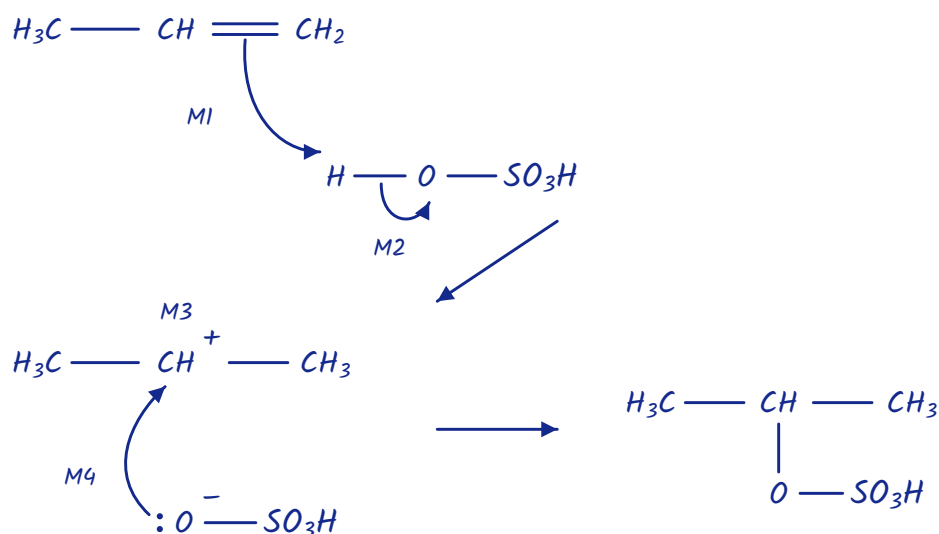
*This induces a dipole in the bromine molecule,  $\text{Br}^{\delta+}-\text{Br}^{\delta-}$ .*



0 1 . 3

Outline a mechanism for the reaction of propene with concentrated sulfuric acid to show the formation of the major product.

[4 marks]



0 1 . 4

Explain why the product of the reaction in Question 01.3 is the major product in the reaction of propene with concentrated sulfuric acid.

[2 marks]

*The major product forms via the secondary carbocation,  $\text{CH}_3\text{C}^+\text{HCH}_3$ ,*

*which is more stable than the primary carbocation,  $\text{CH}_3\text{CH}_2\text{CH}_2^+$ .*

*This is because of the electron-releasing (positive inductive) effect of the two alkyl groups attached to the positive carbon.*

Turn over for the next question

Turn over ►

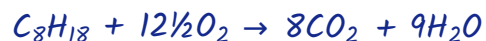


**0 2**

Alkanes undergo combustion reactions and substitution reactions.

**0 2 . 1**

Write an equation for the complete combustion of octane.

**[1 mark]****0 2 . 2**

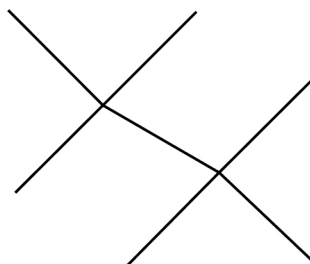
State why the complete combustion of octane may contribute to environmental problems.

**[1 mark]**

*The carbon dioxide produced is a greenhouse gas, so it contributes to global warming.*

**0 2 . 3**

The skeletal formula of an isomer of octane is shown.



Give the IUPAC name for this isomer.

**[1 mark]**

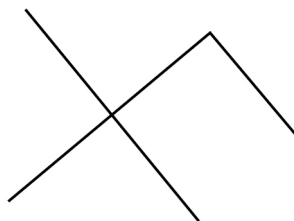
*2,2,3,3-tetramethylbutane*

**0 2 . 4**Explain why the isomer of octane shown in Question **02.3** has a lower boiling point than octane.**[2 marks]**

*The branched isomer is more spherical, with a smaller surface area of contact between molecules, so the van der Waals forces between its molecules are weaker and need less energy to overcome.*



The skeletal formula of compound **Y** is shown.



**Y** reacts with chlorine in a free radical substitution reaction.

**0 2 . 5** State what is meant by the term **free radical**.

[1 mark]

*A species with an unpaired electron.*

**0 2 . 6** Give an equation for each of the propagation steps in the free radical reaction of **Y** ( $C_6H_{14}$ ) with chlorine to form  $C_6H_{13}Cl$

You should use molecular formulae in your equations.

[2 marks]

Propagation step 1



Propagation step 2



Question 2 continues on the next page

Turn over ►



0 2 7

Deduce the number of position isomers that can be formed when **Y** reacts with chlorine to form  $\text{C}_6\text{H}_{12}\text{Cl}_2$

Tick (✓) **one** box.

[1 mark]

4

☐

5

☐

6

☐

7

☒

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0 3

This question is about elimination reactions.

0 3 . 1

But-2-ene can be produced from 2-bromobutane in an elimination reaction.

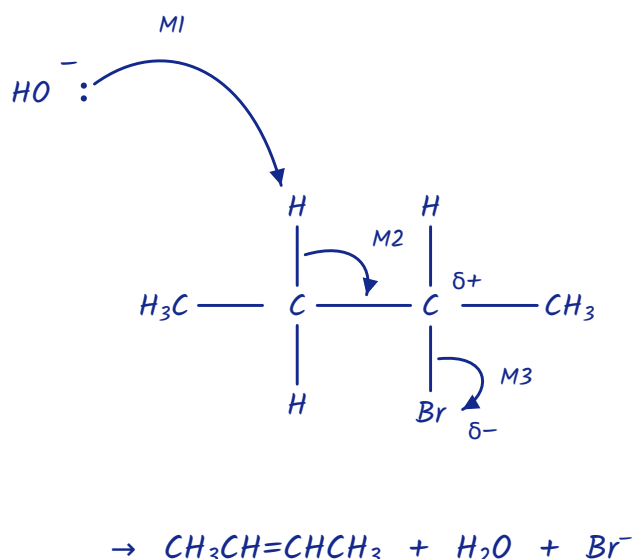
Give the reagent and state a suitable condition for this reaction.

Outline the mechanism.

[5 marks]

Reagent Sodium hydroxide, NaOH (or KOH)Condition Dissolved in ethanol (ethanolic), heated under reflux

Mechanism



0 3 . 2

Identify a structural isomer of but-2-ene that is also formed in the reaction in Question 03.1

Explain your answer.

[2 marks]

Structural isomer formed But-1-ene,  $\text{CH}_2=\text{CHCH}_2\text{CH}_3$ 

Explanation The H can be removed from either carbon next to the C-Br carbon. If an H is removed from C1 instead of C3, the double bond forms between C1 and C2, giving but-1-ene.



0 3 . 3

An alkene can also be formed when an alcohol undergoes an elimination reaction.

Identify a reagent for this reaction.

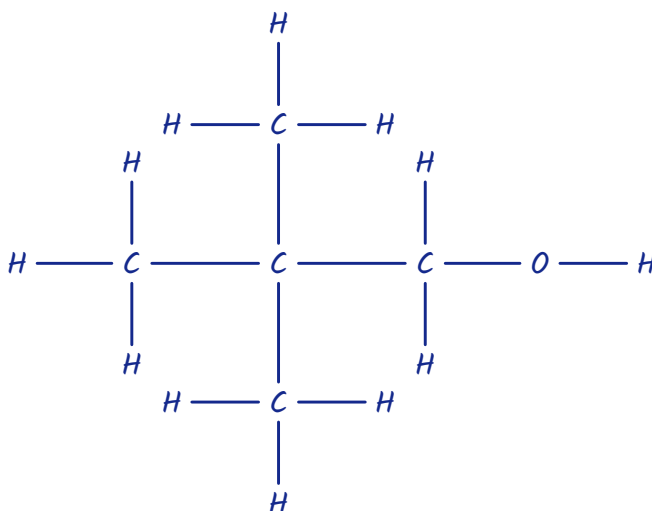
[1 mark]

Concentrated sulfuric acid,  $H_2SO_4$  (or concentrated  $H_3PO_4$ )

0 3 . 4

Give the displayed formula of an alcohol with molecular formula  $C_5H_{12}O$  that does **not** undergo an elimination reaction to form an alkene.

[1 mark]



(2,2-dimethylpropan-1-ol)

9

Turn over for the next question

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0 4

The following pairs of compounds can be distinguished by simple test-tube reactions.

Give a reagent, or combination of reagents, that can be added to the compounds in each pair to distinguish between them.  
State what is observed in each case.

0 4 . 1

Hexane and hex-2-ene.

[3 marks]

Reagent Bromine water,  $\text{Br}_2(\text{aq})$

Observation with hexane No visible change, stays orange

Observation with hex-2-ene Decolourised: orange to colourless

0 4 . 2

Propanone and propanal

[3 marks]

Reagent Tollens' reagent (ammoniacal silver nitrate)

Observation with propanone No visible change

Observation with propanal Silver mirror forms

0 4 . 3

Propan-2-ol and 2-methylpropan-2-ol

[3 marks]

Reagent Acidified potassium dichromate(VI) solution

Observation with propan-2-ol Turns from orange to green

Observation with 2-methylpropan-2-ol No visible change, stays orange

0 4 . 4

Iodoethane and ethanoic acid

[3 marks]

Reagent Sodium carbonate solution,  $\text{Na}_2\text{CO}_3(\text{aq})$

Observation with iodoethane No visible change

Observation with ethanoic acid Effervescence ( $\text{CO}_2$  gas given off)



0 4 . 5

A mass spectrometer can be used to determine the molecular formulae of compounds.

**Table 1** shows some relative atomic mass values to four decimal places.

**Table 1**

| Element  | Relative atomic mass |
|----------|----------------------|
| Carbon   | 12.0096              |
| Hydrogen | 1.0078               |
| Oxygen   | 15.9994              |

Show, by calculation, how these relative atomic masses can be used to distinguish between pentane and butanal.

**[2 marks]**

$$M_r(\text{pentane, } C_5H_{12}) = (5 \times 12.0096) + (12 \times 1.0078) = 72.1416$$

$$M_r(\text{butanal, } C_4H_8O) = 48.0384 + 8.0624 + 15.9994 = 72.1002$$

Both have  $M_r = 72$  to the nearest whole number, but the precise values differ, so high resolution mass spectrometry can distinguish them.

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0 5

Epoxyethane is an important compound used in synthesis.

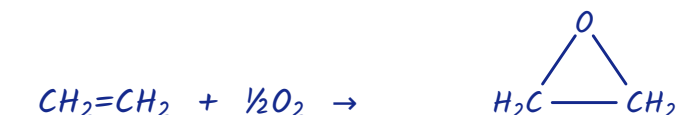
0 5 . 1

Write an equation to show the formation of epoxyethane from ethene.

State the type of reaction occurring.

[2 marks]

Equation

Type of reaction Oxidation

0 5 . 2

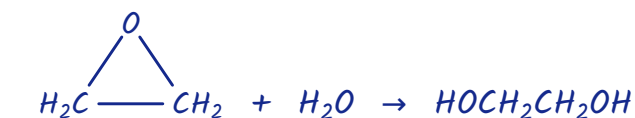
Ethane-1,2-diol is formed when epoxyethane reacts with water.

Write an equation for this reaction.

Give a use for ethane-1,2-diol.

[2 marks]

Equation

Use for ethane-1,2-diol Antifreeze (in car engines)

0 5 . 3

Ethane-1,2-diol can also be formed from 1,2-dibromoethane.

Identify a reagent for this reaction.

State the type of reaction occurring.

[2 marks]

Reagent Sodium hydroxide, NaOH (aqueous)Type of reaction Nucleophilic substitution

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**0 6**

When anhydrous calcium chloride dissolves in water, an exothermic process occurs. A student carried out an experiment to measure the enthalpy change when a sample of anhydrous calcium chloride was added to water.

- The temperature of 50.0 cm<sup>3</sup> of water was measured every minute for three minutes. Before recording the temperature, the water was stirred with the thermometer.
- At the fourth minute, 2.00 g of anhydrous calcium chloride were added to the water. The mixture was stirred but the temperature was not recorded.
- At the fifth minute, the temperature was recorded.
- Stirring and recording the temperature at one-minute intervals continued for seven more minutes.

**0 6****. 1**

State the meaning of the term **enthalpy change**.

**[1 mark]**

*The heat energy change (for a reaction) measured at constant pressure.*

**0 6****. 2**

The student used a balance, a thermometer and a stopclock in the experiment. Identify **one** other piece of apparatus essential to achieve an accurate result.

**[1 mark]**

*A pipette (or burette) to measure the 50.0 cm<sup>3</sup> of water*

**0 6****. 3**

Explain why it is important that the reaction mixture is stirred before recording each temperature.

**[1 mark]**

*To make sure all of the solution is at the same temperature, so the reading is representative of the whole mixture.*



06.4

A graph of temperature versus time was plotted for the data collected. The lines before and after the addition of calcium chloride were extrapolated to the fourth minute. Using these lines, the temperature rise at the fourth minute was found to be 7.0°C.

Calculate the heat released, in kJ, in this experiment.

Assume that:

- the density of the solution is 1.00 g cm<sup>-3</sup>
- the specific heat capacity of the solution is 4.18 J K<sup>-1</sup>g<sup>-1</sup>
- all heat released is used to heat the solution.

[2 marks]

$$q = mc\Delta T = 50.0 \times 4.18 \times 7.0$$

$$q = 1463 \text{ J} = 1.463 \text{ kJ}$$

Heat released 1.46 kJ

06.5

Calculate the amount, in moles, of calcium chloride in 2.00 g of anhydrous calcium chloride.

[1 mark]

$$M_r(\text{CaCl}_2) = 40.1 + (2 \times 35.5) = 111.1$$

$$n = 2.00 \div 111.1 = 0.0180 \text{ mol}$$

Amount 0.0180 mol

06.6

Calculate a value for the enthalpy change, in kJ mol<sup>-1</sup>, in this experiment. Use your answers from Questions 06.4 and 06.5

(If you were unable to answer Questions 06.4 and 06.5, you should use the values 2.0 kJ and 0.024 mol. These are **not** the correct answers.)

[2 marks]

$$\Delta H = -q \div n = -1.463 \div 0.0180$$

$$\Delta H = -81.3 \text{ kJ mol}^{-1} \text{ (negative as exothermic)}$$

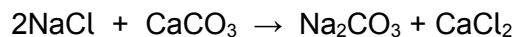
Enthalpy change -81.3 kJ mol<sup>-1</sup>

Turn over ►



0 6 . 7

Calcium chloride can be made by reacting limestone with sodium chloride in a multi-stage reaction which can be represented by the following overall equation.



The standard enthalpy change for this reaction can be calculated using standard enthalpies of formation, and by applying Hess's law.

Give the meaning of the term **standard enthalpy of formation**.  
State Hess's law.

[3 marks]

Standard enthalpy of formation The enthalpy change when one mole of a  
substance is formed from its constituent elements, with all substances  
in their standard states, under standard conditions (100 kPa and a  
stated temperature, usually 298 K).

Hess's law The enthalpy change for a reaction is independent of the  
route taken (it depends only on the initial and final states).



0 6 . 8

Calculate the standard enthalpy change for the reaction between sodium chloride and calcium carbonate.

Use Hess's law and the standard enthalpies of formation given below in **Table 2**.

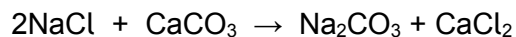


**Table 2**

|                                           | CaCl <sub>2</sub> | CaCO <sub>3</sub> | NaCl  | Na <sub>2</sub> CO <sub>3</sub> |
|-------------------------------------------|-------------------|-------------------|-------|---------------------------------|
| $\Delta_f H^\ominus / \text{kJ mol}^{-1}$ | - 795             | - 1207            | - 411 | - 1131                          |

$$\Delta H = \Sigma \Delta_f H(\text{products}) - \Sigma \Delta_f H(\text{reactants})$$

**[3 marks]**

$$\begin{aligned} \Delta H &= [\Delta_f H(\text{Na}_2\text{CO}_3) + \Delta_f H(\text{CaCl}_2)] \\ &\quad - [2\Delta_f H(\text{NaCl}) + \Delta_f H(\text{CaCO}_3)] \end{aligned}$$

$$\Delta H = (-1131 + (-795)) - ((2 \times -411) + (-1207))$$

$$\Delta H = (-1926) - (-2029)$$

$$\Delta H = +103 \text{ kJ mol}^{-1}$$

Enthalpy change +103 kJ mol<sup>-1</sup>

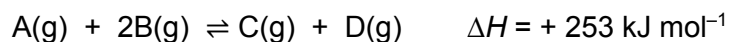
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|---|---|
| 0 | 7 |
|---|---|

This question is about the equilibrium:



|   |   |   |   |
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Write an expression for  $K_c$  for the equilibrium.

Deduce the units of  $K_c$  for this equilibrium.

[2 marks]

$$K_c = \frac{[\text{C}] [\text{D}]}{[\text{A}] [\text{B}]^2}$$

Units:  $\text{mol}^{-1} \text{ dm}^3$

|   |   |   |   |
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Predict the effect, if any, on the value of  $K_c$  for this equilibrium of:

- increasing the temperature
- increasing the volume of the flask
- adding a catalyst.

[3 marks]

Increasing the temperature Increases

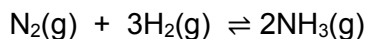
Increasing the volume of the flask No effect

Adding a catalyst No effect



07.3

Nitrogen reacts with hydrogen to form ammonia as shown in the equation.



Samples of ammonia, nitrogen and hydrogen were placed in a reaction flask of volume  $1.50 \text{ dm}^3$  and allowed to reach equilibrium.

The equilibrium mixture was found to contain  $0.975 \text{ mol}$  of hydrogen and  $0.060 \text{ mol}$  of nitrogen. The value of  $K_c$  at this temperature is  $9.60 \text{ mol}^{-2} \text{ dm}^6$

Calculate the concentration of ammonia in the equilibrium mixture.

[4 marks]

$$K_c = [\text{NH}_3]^2 \div ([\text{N}_2][\text{H}_2]^3)$$

$$[\text{N}_2] = 0.060 \div 1.50 = 0.0400 \text{ mol dm}^{-3}$$

$$[\text{H}_2] = 0.975 \div 1.50 = 0.650 \text{ mol dm}^{-3}$$

$$[\text{NH}_3]^2 = K_c \times [\text{N}_2] \times [\text{H}_2]^3$$

$$[\text{NH}_3]^2 = 9.60 \times 0.0400 \times (0.650)^3 = 0.1055$$

$$[\text{NH}_3] = \sqrt{0.1055} = 0.325 \text{ mol dm}^{-3}$$

Concentration of ammonia 0.325 mol  $\text{dm}^{-3}$

9

**END OF QUESTIONS**



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