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Pearson Centre Number Candidate Number

Edexcel GCE

Chemistry
Advanced Subsidiary
Paper 2: Core Organic and Physical Chemistry

Friday 25 May 2018 – Morning Time: 1 hour 30 minutes	Paper Reference 8CH0/02
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Candidates must have: Data Booklet Scientific calculator	Total Marks
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Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- For the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Check your answers if you have time at the end.
- Show all your working in calculations and include units where appropriate.

Turn over ►

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Answer ALL questions.

Some questions must be answered with a cross .
If you change your mind about an answer, put a line through the box
and then mark your new answer with a cross .

1 Which of the following does **not** act as a nucleophile?

- A HBr
- B H₂O
- C NH₃
- D CN⁻

(Total for Question 1 = 1 mark)

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2 This question is about the molar volume of gases.

- (a) (i) Calculate the volume of one mole of an ideal gas, **A**, at 60 °C and 500 kPa pressure. Give your answer to two significant figures and include units.

[The ideal gas equation is $pV = nRT$. Gas constant (R) = 8.31 JK⁻¹ mol⁻¹]

(3)

- (ii) At room temperature and pressure (r.t.p) another gas **B**, with formula XH₃, has a density of 1.42 g dm⁻³.

Calculate the molar mass of the gas XH₃ and deduce the identity of the element X.

[The molar volume of gas **B** = 24 000 cm³ mol⁻¹ at r.t.p.]

(2)

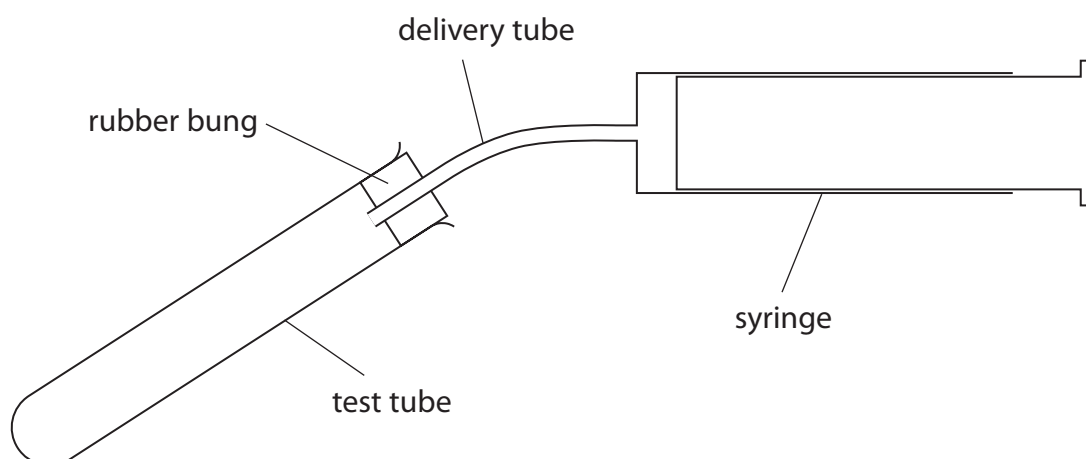
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- (b) The apparatus shown was used to measure the volume of gas evolved when a weighed mass of sodium carbonate reacted with dilute hydrochloric acid.



The following procedure was used.

Step 1 Solid sodium carbonate was placed in a container and weighed accurately.

Step 2 The delivery tube and rubber bung were removed and the sodium carbonate was transferred to the test tube.

Step 3 The container was then reweighed.

Step 4 The syringe plunger was pushed in, to zero the syringe.

Step 5 10.0 cm^3 of $0.400 \text{ mol dm}^{-3}$ hydrochloric acid was then added to the sodium carbonate and the rubber bung and delivery tube rapidly replaced.

Step 6 The mixture was shaken and, when the reaction had finished, the reading of the syringe was noted.

Results

Mass of container and sodium carbonate before transfer = 20.135 g

Mass of container after transfer of the sodium carbonate = 19.893 g

Mass of sodium carbonate used = 0.242 g

The equation for the reaction is



- (i) Calculate the moles of hydrochloric acid and the moles of sodium carbonate used in this experiment.

Use your answers to decide which reactant is in excess.

Calculate the maximum volume of carbon dioxide which could be produced.

$$\left[\begin{array}{l} \text{Molar mass of Na}_2\text{CO}_3 = 106.0 \text{ g mol}^{-1} \\ \text{Molar volume of gas} = 24\,000 \text{ cm}^3 \text{ mol}^{-1} \text{ at r.t.p.} \end{array} \right] \quad (5)$$

- (ii) The actual volume of carbon dioxide collected was less than calculated.
Give **two** reasons for this.

(2)

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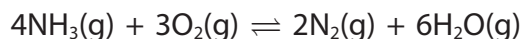
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(Total for Question 2 = 12 marks)



3 This question is about the oxidation of ammonia.

One equation for the oxidation of ammonia is

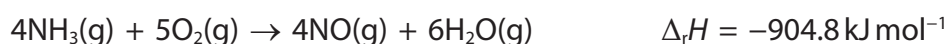


(a) Write the expression, including units, for the equilibrium constant K_c for this reaction. (2)

Expression

Units

(b) Nitric acid is made from ammonia. One of the stages in nitric acid production involves the oxidation of ammonia to produce nitrogen(II) oxide, NO. In this process, a mixture of ammonia and oxygen is passed over a platinum-rhodium catalyst. One manufacturer uses a pressure of 5 atm and a temperature of 850 °C. The equation for this reaction is different from that in 3(a).



(i) Use this equation, and the enthalpy changes of formation of nitrogen(II) oxide and water, to calculate the enthalpy change of formation of ammonia in kJ mol^{-1} . You may find it helpful to draw a Hess cycle first. You must show your working.

$$\Delta_f H (\text{NO}(\text{g})) = +90.4 \text{ kJ mol}^{-1}$$

$$\Delta_f H (\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ mol}^{-1}$$

(3)

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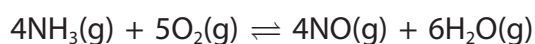


- (ii) Calculate the atom economy by mass for the formation of NO in this reaction.
Give your answer to an appropriate number of significant figures.

(2)

- (c) In fact, this oxidation to form nitrogen(II) oxide is an equilibrium reaction.

- (i) Explain the effect, if any, of increasing pressure on the equilibrium **yield** of NO in this reaction.



(2)

- (ii) Explain the effect, if any, of an increase in pressure on the **rate** of this reaction.

(2)

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- (iii) The platinum-rhodium catalyst used in this reaction is a **heterogeneous** catalyst. State what is meant by the term 'heterogeneous' and why a catalyst has no effect on the yield of the products in the reaction.

(2)

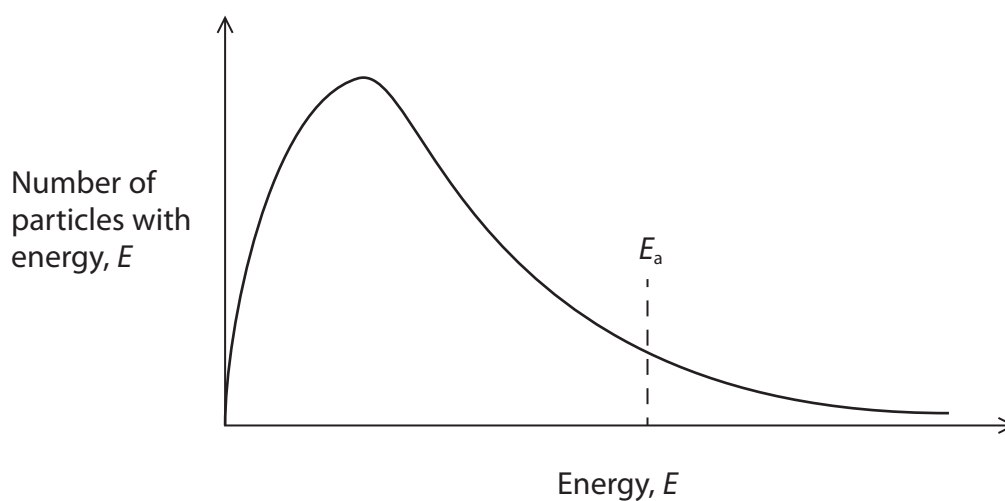
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- (d) The diagram shows a Maxwell-Boltzmann distribution of particle energies, including the activation energy, E_a , for a reaction.

(1)



An increase in temperature will

- A** increase the area under the curve.
- B** move the peak of the curve to the right.
- C** raise the height of the peak.
- D** move the position of the activation energy, E_a , to the left.

(Total for Question 3 = 14 marks)



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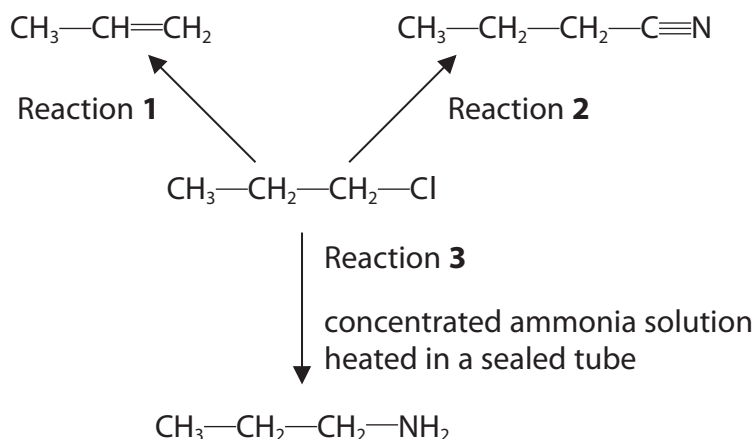
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4 This question concerns halogenoalkanes.

(a) 1-chloropropane can react to form organic products as shown in the reaction scheme:



(i) State the reagent and conditions used in Reaction 1.

(2)

(ii) Identify a suitable reagent for Reaction 2 and include a reason why this is a particularly useful type of reaction in organic chemistry.

(2)

Reagent

Reason

(iii) Explain why, in Reaction 3, the reactants are **heated** in a **sealed** container.

(2)

(iv) Write the structural formula of the product that will be formed if 1-chloropropane is refluxed with **aqueous** potassium hydroxide solution.

(1)

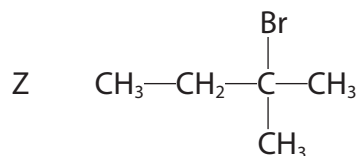
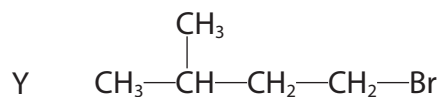
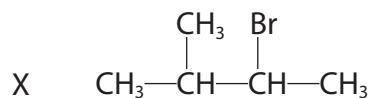
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- (b) The bromoalkanes, X, Y and Z, were each added to a mixture of aqueous silver nitrate and ethanol at 50 °C. The rate of hydrolysis was compared by measuring the time for a precipitate to appear.



The relative rates of hydrolysis are in the order (fastest first)

(1)

- A X, Y, Z
- B Z, X, Y
- C Z, Y, X
- D X, Z, Y

(Total for Question 4 = 8 marks)



5 This question concerns alkenes and some halogen compounds.

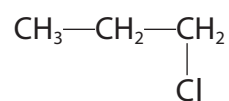
(a) The alkene, propene, reacts with hydrogen chloride.

(i) This reaction is best described as

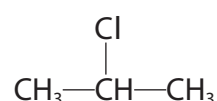
(1)

- A electrophilic substitution
- B electrophilic addition
- C nucleophilic substitution
- D nucleophilic addition

(ii) The reaction of propene with hydrogen chloride can produce two isomeric products:



1-chloropropane



2-chloropropane

1-chloropropane and 2-chloropropane are

(1)

- A *cis-trans* isomers
- B *E/Z* isomers
- C structural isomers
- D stereoisomers

(iii) Draw the mechanism for the reaction of propene with hydrogen chloride to produce 2-chloropropane. Include curly arrows, and any relevant dipoles and lone pairs.

(4)

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(b) The halogenoalkane chloroethene is used to make the important polymer poly(chloroethene), PVC.

(i) Draw a **displayed** formula of two repeat units of poly(chloroethene).

(1)

(ii) Some polymers are disposed of by incineration. Ignoring any economic considerations, explain why incineration is **not** a suitable method for the disposal of poly(chloroethene).

(2)

(iii) Chloroethene has a boiling temperature of 260 K and is known to be carcinogenic. Use these facts to state **one** precaution that chemists should take when using this compound.

(1)

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(c) Chloroethene can be manufactured by a two-stage process.

(i) In stage 1, chlorine is reacted with ethene at a temperature between 50°C and 80°C



Give **one** reason why a temperature below 50°C and **another** reason, apart from costs, why a temperature above 80°C would not be used for this process.

(2)

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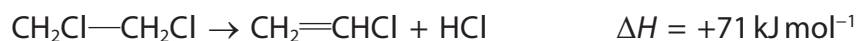
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(ii) In stage 2, the product from the first reaction is converted to chloroethene:



Both products are required for use in other processes.

Which method would be most suitable for the separation of these two products?

(1)

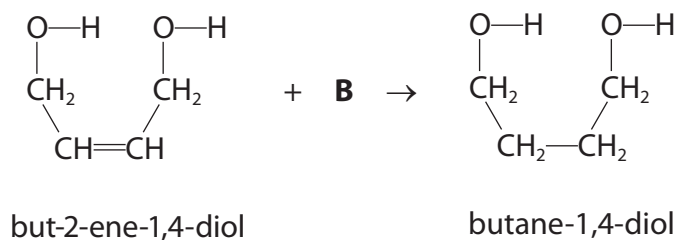
- A fractional distillation
- B solvent extraction using a separating funnel
- C heating under reflux
- D bubble through dilute alkali

(Total for Question 5 = 13 marks)



6 This question is about the synthesis and reactions of butane-1,4-diol.

- (a) Butane-1,4-diol can be synthesised from but-2-ene-1,4-diol, by reaction with a reagent, **B**.



- (i) Identify reagent **B** and state suitable conditions for this reaction.

(2)

- (ii) This reaction is best described as

(1)

- A** hydrolysis
- B** oxidation
- C** reduction
- D** substitution

- (iii) Name **one** other commercially important product that can be manufactured by this type of reaction with the alkene group.

(1)

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*(b) Butane-1,4-diol can be oxidised to form butanedioic acid. The molecular formula of butanedioic acid is $C_4H_6O_4$ and it is a solid at room temperature.

Describe how you would make 250 cm^3 of a solution of butanedioic acid with an accurately known concentration of approximately $0.0500\text{ mol dm}^{-3}$.
Butanedioic acid is sufficiently soluble in water to achieve this concentration.

[Molar mass of butanedioic acid = 118 g mol^{-1}]

(6)

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(Total for Question 6 = 10 marks)



7 This question is about the titration of a weak acid with a strong base.

- (a) A standard solution of ethanedioic acid, which is a weak, diprotic acid, can be used to determine the concentration of a sodium hydroxide solution. 25.0 cm^3 of the ethanedioic acid solution, with concentration 3.80 g dm^{-3} , was pipetted into a conical flask. A few drops of indicator solution were added. The ethanedioic acid was titrated with the sodium hydroxide solution which was in the burette. The titration was repeated and the following results were obtained.

[Molar mass of ethanedioic acid = 90.0 g mol^{-1}]

	Titration 1	Titration 2	Titration 3	Titration 4
Final reading / cm^3	18.00	17.60	35.30	27.70
Initial reading / cm^3	0.00	0.00	17.60	10.05
Titre / cm^3	18.00	17.60	17.70	17.65
Titre used to find the mean titre (✓)				
			Mean titre / cm^3	

- (i) In the appropriate row, tick (✓) those titre values that should be used to find the mean, and use these titres to calculate it.

Write the value of the mean titre in the box provided in the table of results.

(2)

- (ii) Ethanedioic acid is a weak acid. Name a suitable indicator for this titration and state the colour change at the end-point.

(2)

Name of indicator

Colour change at the end-point from to

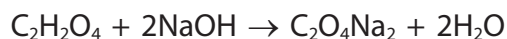
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(iii) The equation for the reaction of ethanedioic acid with sodium hydroxide is



Calculate the concentration of the sodium hydroxide solution, in mol dm^{-3} .
Give your answer to **three** significant figures.

(4)

(b) The uncertainty in each burette reading is $\pm 0.05 \text{ cm}^3$. The uncertainty in the pipette volume is $\pm 0.06 \text{ cm}^3$.

(i) Calculate the percentage uncertainties for titre 4, and the pipette volume.

(2)

(ii) Which of the following changes would halve the percentage uncertainty in the volume of liquid measured by the burette?

(1)

- A halve the acid concentration and halve the acid volume
- B double the acid concentration and leave the acid volume unchanged
- C double the acid concentration and halve the acid volume
- D halve the acid concentration and leave the acid volume unchanged

(Total for Question 7 = 11 marks)

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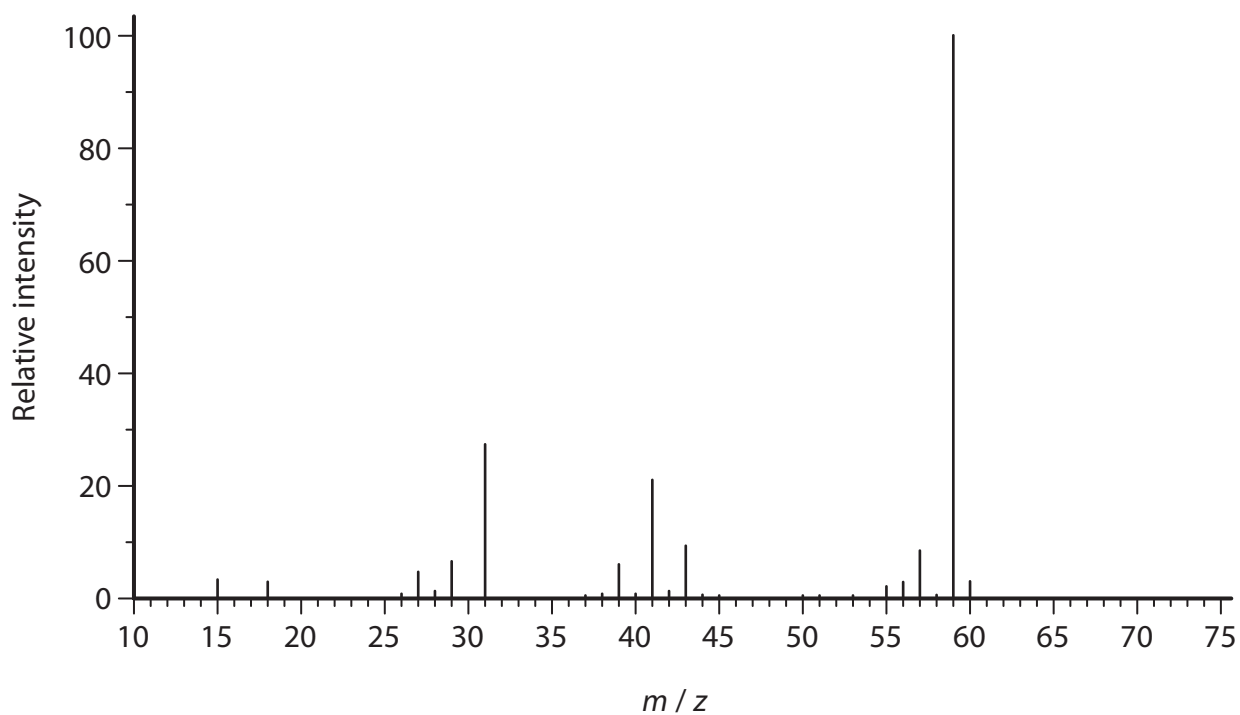
8 This question is about 2-methylpropan-2-ol.

(a) Draw the fully **displayed** formula of 2-methylpropan-2-ol.

(1)

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(b) The mass spectrum of 2-methylpropan-2-ol is shown.



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(i) The relative molecular mass of 2-methylpropan-2-ol is 74. Give a possible reason why there is no molecular ion peak in the mass spectrum of 2-methylpropan-2-ol.

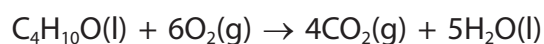
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- (ii) Write the formula for a species that could be responsible for the peak at $m/z = 59$.
(1)

- (c) The equation for the complete combustion of 2-methylpropan-2-ol is



- (i) Using the bond enthalpies shown in the table, calculate a value for the enthalpy change, in kJ mol^{-1} , for the complete combustion of 2-methylpropan-2-ol.

(4)

Bond	Mean bond enthalpy / kJ mol^{-1}
C—C	347
C—H	413
C—O	358
O—H	464
O=O	498
C=O	805

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(ii) 2-methylpropan-2-ol burns in air with a smoky flame. Explain how burning with a smoky flame affects the value of the experimentally determined enthalpy change of combustion.

(2)

(iii) A Data Book value for the enthalpy change of combustion of 2-methylpropan-2-ol is $-2643.8 \text{ kJ mol}^{-1}$. Give the main reason for the difference between this value and your answer to part 8(c)(i).

(1)

(d) Which observation would be expected when 2-methylpropan-2-ol is heated with potassium dichromate(VI) and dilute sulfuric acid?

(1)

- A orange to green
- B green to orange
- C purple to colourless
- D no change

(Total for Question 8 = 11 marks)

TOTAL FOR PAPER = 80 MARKS

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