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Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Paper 2: Core Organic and Physical Chemistry

Sample Assessment Materials for first teaching September 2015

Time: 1 hour 30 minutes

Paper Reference **8CH0/02**

You must have:
Data Booklet
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or 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.*
- You may use a scientific calculator.
- For questions marked with an *****, 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.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- 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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PEARSON

Answer ALL questions.

Write your answers in the spaces provided.

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

1 Methylpropane is an alkane.

(a) Draw the displayed formula of methylpropane.

(1)

(b) Give the empirical formula of methylpropane.

(1)

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(c) A partially balanced equation for the complete combustion of butane is:

$$C_4H_{10} + xO_2 \rightarrow 4CO_2 + 5H_2O$$

The number of moles of oxygen, *x*, needed to balance this equation is

(1)

- ☒ **A** 4.5
- ☒ **B** 6.5
- ☒ **C** 9
- ☒ **D** 13

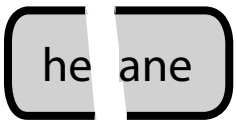
(d) Incomplete combustion of butane produces a mixture of products.

Which substance is **not** produced during the incomplete combustion of butane?

(1)

- ☒ **A** C
- ☒ **B** CO
- ☒ **C** H_2
- ☒ **D** H_2O

(e) A student is given a bottle, containing an alkane, with an incomplete label.



The student realises that the alkane could be hexane or heptane and wants to identify it.

The student injects a sample of the liquid, with a mass of 0.235 g, into a sealed gas syringe. The syringe is placed in an oven at 425 K and the liquid vaporises. The volume of the gas produced is 83 cm^3 at a pressure of 100 kPa (100 000 N m^{-2})

Identify the alkane. Justify your answer by the use of a calculation.

(4)

(Total for Question 1 = 8 marks)

2 The equations for three reactions are:

reaction 1 $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta_r H^{\ominus} = -394 \text{ kJ mol}^{-1}$

reaction 2 $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ $\Delta_r H^{\ominus} = -890 \text{ kJ mol}^{-1}$

reaction 3 $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta_r H^{\ominus} = -572 \text{ kJ mol}^{-1}$

(a) Give **two** reasons why all three reactions are classified as examples of combustion.

(2)

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(b) Only reaction 1 represents a standard enthalpy change of formation.

Give reasons why reactions 2 and 3 do not.

(2)

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(c) Which physical property should be kept constant when measuring an enthalpy change?

(1)

- ☒ **A** concentration
- ☒ **B** pressure
- ☒ **C** temperature
- ☒ **D** volume

(d) A reaction occurs under standard conditions.
Which of these represents a possible standard condition?

(1)

- ☒ **A** 1 g cm^{-3}
- ☒ **B** 4.18 J g^{-1} K^{-1}
- ☒ **C** 24 dm^3
- ☒ **D** 298 K

(Total for Question 2 = 6 marks)

3 Ammonia is used in the manufacture of nitric acid.

The equation for one step in this manufacturing process is:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \quad \Delta_r H = -900 \text{ kJ mol}^{-1}$$

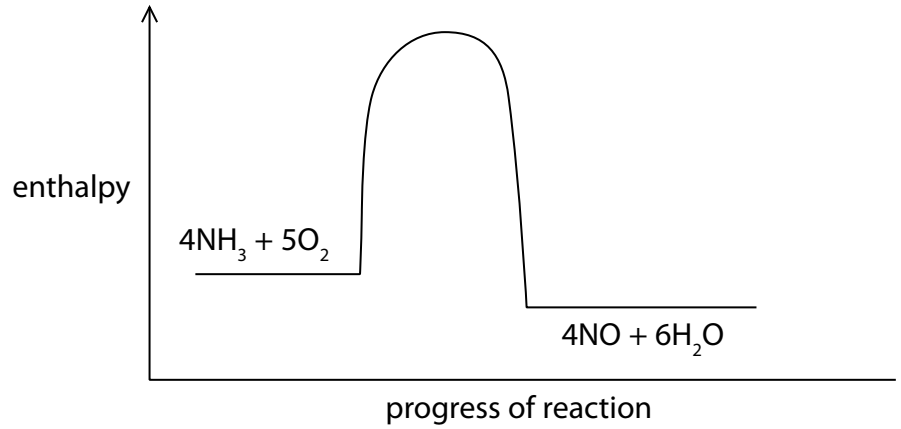
* a) A manufacturer carries out this reaction at a temperature of 1200 K and a pressure of 10 atm. A scientist proposes that a temperature of 1000 K should be used at the same pressure.

Evaluate the effects of making this change on the rate and yield of this reaction.

(6)

(b) When this reaction is used in industry, the catalyst is an alloy of platinum and rhodium.

The diagram shows the reaction profile for the uncatalysed reaction.



(i) On the diagram, draw the reaction profile for the catalysed reaction.

(1)

(ii) Label the diagram to show

- the enthalpy change, $\Delta_r H$
- the activation energy, E_a

for the catalysed reaction.

(2)

(c) Write the expression for the equilibrium constant, K_c, for this reaction.

(1)

(Total for Question 3 = 10 marks)

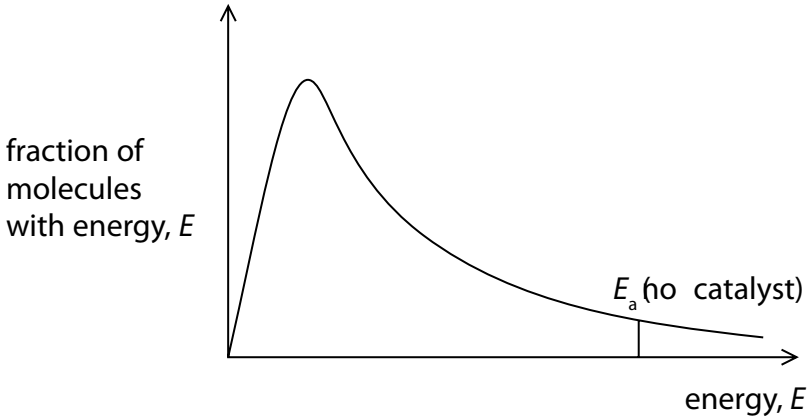
4 This question is about the thermal decomposition of ammonia.

This reaction is catalysed by platinum and is represented by the equation:

$$2NH_3(g) \rightarrow N_2(g) + 3H_2(g) \qquad \Delta_r H^{\ominus} = +92 \text{ kJ mol}^{-1}$$

The diagram shows a sketch of the Maxwell-Boltzmann curve for the distribution of molecular energies for a fixed amount of ammonia gas at a given temperature.

E_a represents the activation energy of the uncatalysed reaction.



(a) (i) On the diagram, draw a vertical line to represent the activation energy of the catalysed reaction. Label this line E_a (with catalyst)

(1)

(ii) Use the diagram to explain why the use of a catalyst increases the rate of decomposition of ammonia.

(3)

(b) The table shows the bond enthalpies for the N≡N and H–H bonds.

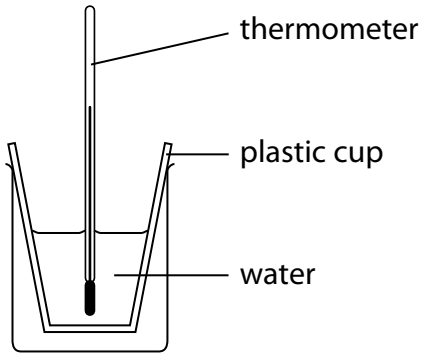
Bond	Bond enthalpy / kJ mol^{-1}
N≡N	+944
H–H	+436

Use this data, together with the standard enthalpy change of reaction, $\Delta_r H^{\ominus}$, for the decomposition of ammonia, to calculate a value, in kJ mol^{-1}, for the mean bond enthalpy of the N–H bond in ammonia.

(3)

(Total for Question 4 = 7 marks)

5 Some reactions involving copper(II) sulfate are investigated.
The diagram shows the apparatus used to measure the temperature change when anhydrous copper(II) sulfate, $CuSO_4(s)$, is dissolved in water.



The chemical change can be represented by this equation:

$$CuSO_4(s) + aq \rightarrow CuSO_4(aq)$$

The method is:

- Pour some water into the plastic cup and record the steady temperature
- Add some anhydrous copper(II) sulfate and stir until it has all dissolved
- Record the maximum temperature reached in the reaction

These results are recorded.

Mass of water used	50.0 g
Initial temperature of water	18.2 °C
Final temperature of water	25.4 °C
Mass of anhydrous copper(II) sulfate used	4.70 g

(a) Calculate the standard enthalpy change, in kJ mol^{-1}, for the reaction, giving your answer to an appropriate number of significant figures.

(5)

(b) The method used in this experiment leads to an inaccurate value for the temperature change.

Describe an alternative method to find a more accurate value for the temperature change.

(3)

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(c) The experiment is repeated using the same method but with hydrated copper(II) sulfate, $CuSO_4.5H_2O(s)$, as well as with anhydrous copper(II) sulfate.

The same method is used to calculate the standard enthalpy changes for these reactions:

$CuSO_4.5H_2O(s) + aq \rightarrow CuSO_4(aq)$ $\quad \Delta_r H^{\ominus}_1 = +78.5 \text{ kJ mol}^{-1}$

$CuSO_4(s) + aq \rightarrow CuSO_4(aq)$ $\quad \Delta_r H^{\ominus}_2 = -41 \text{ kJ mol}^{-1}$

Calculate the standard enthalpy change for this reaction:

$CuSO_4(s) + aq \rightarrow CuSO_4.5H_2O(s)$

(2)

(d) The experimental value in part (c) of $\Delta_r H^{\ominus}_2 = -41$ kJ mol^{-1} for the reaction involving anhydrous copper(II) sulfate was different from a data book value.

The anhydrous copper(II) sulfate used in this experiment was pale blue, rather than white.

Explain how this observation partly accounts for the difference between the experimental value and the data book value.

(3)

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(Total for Question 5 = 13 marks)

6 A student investigates the rates of hydrolysis of three different halogenoalkanes.
The student uses this method.

- 5 cm^3 of ethanol is put into each of three test tubes and five drops of a different halogenoalkane is added to each.
- The test tubes are placed into a water bath at 50°C .
- 5 cm^3 of aqueous silver nitrate is put into each of three clean test tubes in the water bath.
- When the solutions have reached the temperature of the water bath, 5 cm^3 of the silver nitrate solution is mixed with each test tube containing a halogenoalkane in ethanol. A stop clock is started when the solutions are mixed.
- The time taken for a precipitate to appear in each test tube is recorded in a table.

Halogenoalkane	Time taken for precipitate to appear
1-chlorobutane	20 minutes and 50 seconds
1-bromobutane	9 minutes and 15 seconds
1-iodobutane	5 seconds

(a) (i) State the colour of the precipitate formed in the 1-iodobutane test tube.

(1)

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(ii) Calculate the **relative** rates of reaction for each of the three halogenoalkanes.

(2)

(ii) Explain the relative rates of hydrolysis of 1-chlorobutane and 1-iodobutane in this experiment.

(3)

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(b) The student saw, on a website, a comparison of the rates of hydrolysis of these bromoalkanes:

F $CH_3CH_2CH_2CH_2Br$
G $CH_3CH_2CHBrCH_3$
H $(CH_3)_3CBr$

(i) The correct order for the rates of hydrolysis of these bromoalkanes, showing the fastest first, is:

(1)

☒ **A** **F** > **G** > **H**

☒ **B** **G** > **F** > **H**

☒ **C** **H** > **F** > **G**

☒ **D** **H** > **G** > **F**

(ii) Identify, with a reason, which of **F**, **G** and **H** is a tertiary bromoalkane.

(2)

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(iii) A student said that bromoalkane **F** had the name 4-bromobutane.

Give a reason why this name is incorrect.

(1)

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(Total for Question 6 = 10 marks)

7 But-1-ene and but-2-ene are unsaturated hydrocarbons with the molecular formula C_4H_8.

Each one reacts with a few drops of bromine in an addition reaction.

(a) Give the colour change that occurs in these reactions.

(1)

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(b) (i) Name the type of mechanism for these reactions.

(1)

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(ii) Draw the mechanism for the reaction between but-2-ene and bromine.

(4)

(c) But-1-ene reacts with hydrogen bromide to form two different products.

(i) Analysis of one of the products showed that it contains 34.9% carbon and 6.60% hydrogen by mass.

Calculate the empirical formula of this product.

(3)

(ii) Give the name of the major product of this reaction.

(1)

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(d) The carbon-carbon double bond in but-2-ene can be represented by C═C.

A disadvantage of this representation is that it shows the two covalent bonds to be the same.

However, there are two different types of covalent bond (σ and π) in but-2-ene.

Compare and contrast these two different types of bonds.

(3)

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(e) Draw the skeletal formula of *trans*-but-2-ene.

(1)

(Total for Question 7 = 14 marks)

8 This question is about some isomeric alcohols with molecular formula $C_5H_{12}O$.

(a) The table shows some information about three of these alcohols.
Give the structural formula of each of these alcohols.

(3)

Alcohol	Description	Structural formula
P	the straight-chain primary alcohol	
Q	the secondary alcohol with a branched carbon chain	
R	the alcohol **not** oxidised by potassium dichromate(VI) in dilute sulfuric acid	

(b) **T** is another different isomeric alcohol with the molecular formula $C_5H_{12}O$.
T is a secondary alcohol.

The most prominent peak in the mass spectrum of **T** occurred at $m/z = 45$, with another peak at $m/z = 43$

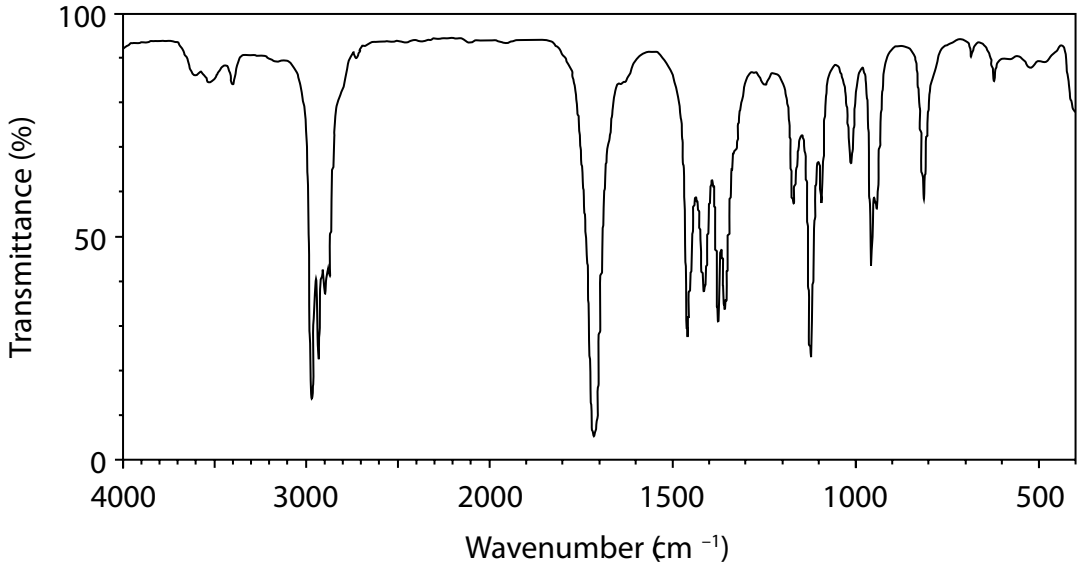
Deduce the structure of **T**. Justify your answer by identifying the structural formula of each fragment ion.

(3)

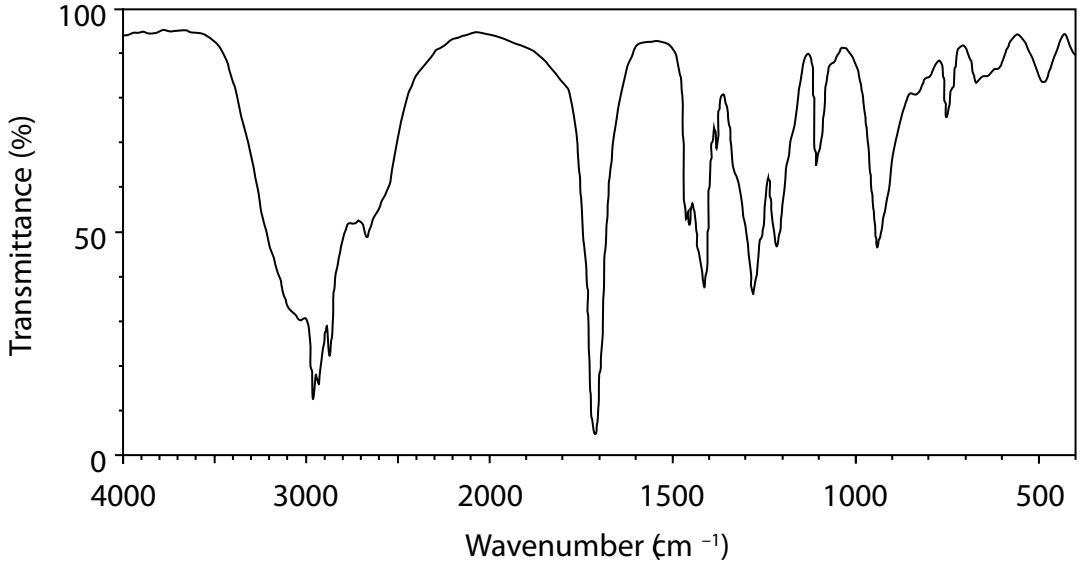
Some of the alcohols were heated with potassium dichromate(VI) and sulfuric acid. The organic compounds were separated from the reaction mixtures and purified.

The infrared spectra of two of these organic compounds are shown.

Compound Y



Compound Z



(c) (i) Deduce, using the table of absorptions from the data booklet, the type of compound responsible for each spectrum.

Include in your answer references to wavenumbers and their corresponding bonds.

(2)

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(ii) One of the two compounds, **Y** and **Z**, of mass 2.74 g is completely burned in oxygen.

Carbon dioxide and water are the only two products.

The masses of carbon dioxide and water formed are 5.89 g and 2.44 g respectively.

Show by calculation that this data is consistent with a formula of $C_5H_{10}O_2$ for this compound.

(4)

(Total for Question 8 = 12 marks)

TOTAL FOR PAPER = 80 MARKS

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