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AS Chemistry

Sample Assessment Materials

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry (8CH0)

First teaching from September 2015

First certification from 2016

Issue 1

edexcel

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry (8CH0)

Sample Assessment Materials

First certification 2016

Edexcel, BTEC and LCCI qualifications

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Contents

1	Introduction	1
2	General marking guidance	3
3	Paper 1 Core Inorganic and Physical Chemistry	5
4	Paper 1 Mark Scheme	33
5	Paper 2 Core Organic and Physical Chemistry	53
6	Paper 2 Mark Scheme	77

Introduction

The Pearson Edexcel Level 3 Advanced Subsidiary GCE in Chemistry is designed for use in schools and colleges. It is part of a suite of GCE qualifications offered by Pearson.

These sample assessment materials have been developed to support this qualification and will be used as the benchmark to develop the assessment students will take.

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the last candidate in exactly the same way as they mark the first.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than be penalised for omissions.
- Examiners should mark according to the mark scheme – not according to their perception of where the grade boundaries may lie.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification/indicative content will not be exhaustive.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, a senior examiner must be consulted before a mark is given.
- Crossed-out work should be marked **unless** the candidate has replaced it with an alternative response.

Write your name here

Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Paper 1: Core Inorganic and Physical Chemistry

Sample Assessment Materials for first teaching September 2015

Time: 1 hour 30 minutes

Paper Reference **8CH0/01**

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.
- A Periodic Table is printed on the back cover of this paper.

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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S 4 7 5 5 1 A 0 1 2 8

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 Many elements in the Periodic Table have different isotopes.

(a) What is meant by the term **isotopes**, with reference to sub-atomic particles?

(2)

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(b) A radioactive compound containing the phosphide ion, $^{32}P^{3-}$, is used in the treatment of skin cancer.

What is the electronic configuration of the phosphide ion, $^{32}P^{3-}$?

(1)

☒ **A** $1s^2 2s^2 2p^6 3s^2$

☒ **B** $1s^2 2s^2 2p^6 3s^2 3p^3$

☒ **C** $1s^2 2s^2 2p^6 3s^2 3p^6$

☒ **D** $1s^2 2s^2 2p^6 3s^2 3p^3 3d^3$

(c) A sample of silicon contains 92.2% ^{28}Si and 4.67% ^{29}Si, the remainder being ^{30}Si.

Calculate the relative atomic mass of silicon in this sample, giving your answer to an appropriate number of significant figures.

(2)

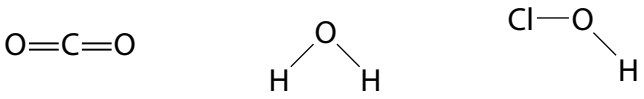
(d) Silicon tetrachloride, $SiCl_4$, is a covalent substance which is a liquid at room temperature.

Calculate the number of molecules in 5.67 g of $SiCl_4$.

(2)

(Total for Question 1 = 7 marks)

2 The molecules carbon dioxide, water and chloric(I) acid can be represented by these structures.



All the bonds in these molecules are polar because the elements have different electronegativities.

(a) In terms of atomic structure, give **two** reasons why oxygen is more electronegative than carbon.

(2)

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(b) Explain why carbon dioxide is the only non-polar molecule of the three.

(2)

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(c) The diagram shows the structure of a water molecule and of a chloric(I) acid molecule.

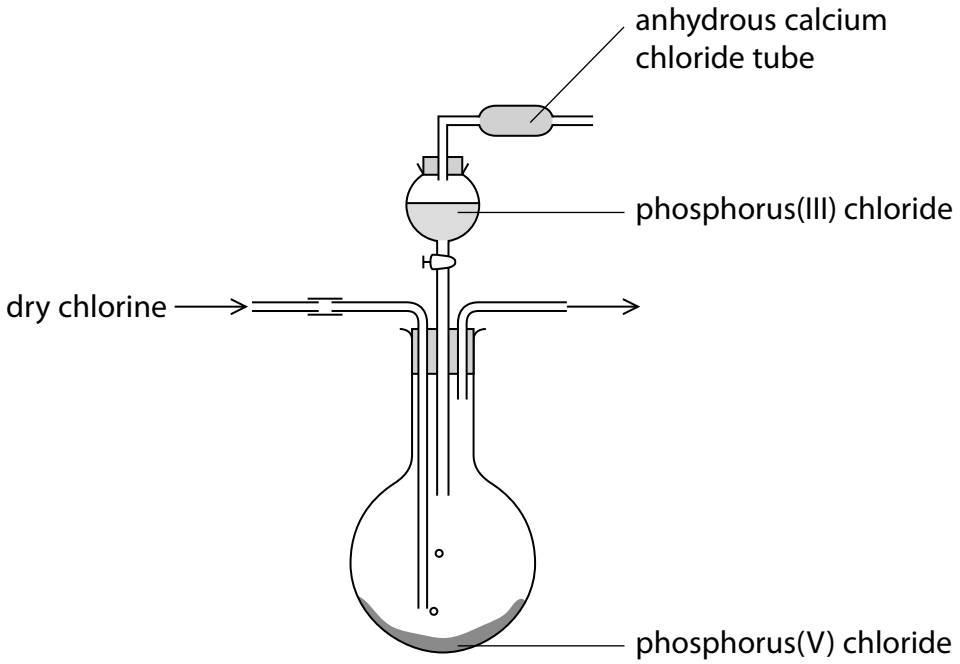
Draw a diagram to show how a hydrogen bond can form between the two molecules.

(2)

(Total for Question 2 = 6 marks)

3 Phosphorus(V) chloride, PCl_5, is a pale yellow solid which sublimes when heated.

Phosphorus(V) chloride may be prepared in the laboratory from dry phosphorus(III) chloride and dry chlorine, using the apparatus shown.



(a) Which statement gives a reason why phosphorus(V) chloride has a higher melting temperature than phosphorus(III) chloride?

(1)

- ☒ **A** PCl_5 contains phosphorus with a higher oxidation number
- ☒ **B** PCl_5 has stronger intermolecular forces
- ☒ **C** PCl_5 molecules have more covalent bonds
- ☒ **D** PCl_5 molecules have stronger covalent bonds

(b) (i) Explain an essential safety precaution for this preparation.

(2)

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(ii) The reaction is exothermic.

Explain how the apparatus could be altered to maximise the formation of the product.

(2)

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(iii) Write an equation for the reaction between phosphorus(III) chloride and chlorine. State symbols are not required.

(1)

(c) 4.17 g of phosphorus(V) chloride is reacted with ethanedioic acid, $H_2C_2O_4$, to form phosphorus oxychloride as shown by the following equation:

$$PCl_5(s) + H_2C_2O_4(s) \rightarrow POCl_3(l) + 2HCl(g) + CO_2(g) + CO(g)$$

The phosphorus oxychloride is then hydrolysed by water as shown by the following equation:

$$POCl_3(l) + 3H_2O(l) \rightarrow H_3PO_4(aq) + 3HCl(g)$$

Calculate the total volume, in dm^3, of hydrogen chloride gas produced by both reactions.

[1 mol of any gas occupies 24.0 dm^3 at room temperature and pressure.]

(3)

(Total for Question 3 = 9 marks)

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4 This question is about disproportionation reactions.

(a) Solutions containing chlorate(I) ions can be used as household bleaches and disinfectants.
These solutions decompose on heating as shown by the following equation:

$$3ClO^-(aq) \rightarrow ClO_3^-(aq) + 2Cl^-(aq)$$

What is the oxidation number of chlorine in each of these three ions?

(1)

	ClO^-	ClO_3^-	Cl^-
☒ **A**	+1	+3	−1
☒ **B**	−1	+3	+1
☒ **C**	−1	+5	+1
☒ **D**	+1	+5	−1

(b) A coin, of mass 5.00 g, contains silver. The coin is dissolved in 500 cm^3 of concentrated nitric acid to form silver nitrate solution, $AgNO_3(aq)$.

50.0 cm^3 of this solution is reacted with excess sodium chloride solution to form a precipitate of silver chloride, AgCl.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

After filtering and drying, the mass of the precipitate was 0.617 g.

Calculate the percentage by mass of silver in the coin. Give your answer to an appropriate number of significant figures.

(4)

(c) Silver nitrate reacts with iodine as shown by the following equation:

$$6AgNO_3(aq) + 3I_2(aq) + 3H_2O(l) \rightarrow AgIO_3(aq) + 5AgI(s) + 6HNO_3(aq)$$

The reaction is classified as a disproportionation reaction.

(i) What is meant by the term **disproportionation**?

(2)

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.....

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.....

(ii) Deduce the element undergoing disproportionation in this reaction.

(1)

☒ **A** Ag

☒ **B** H

☒ **C** I

☒ **D** O

(Total for Question 4 = 8 marks)

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5 Compounds of Group 1 and Group 2 elements show trends in their properties.

(a) Which block of the Periodic Table contains the Group 2 elements?

(1)

- ☒ **A** *s*
- ☒ **B** *p*
- ☒ **C** *d*
- ☒ **D** *f*

(b) Some rocks contain the compound strontium carbonate, $SrCO_3$.

(i) Which of the following could represent successive ionisation energies, in kJ mol^{-1}, for the Group 2 element strontium (Sr)?

(1)

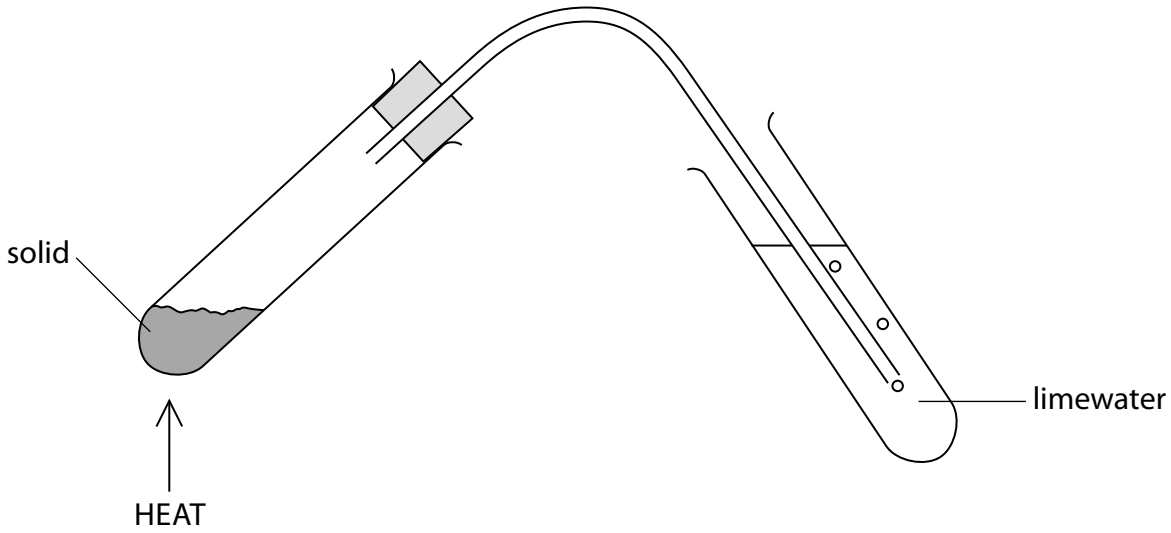
- ☒ **A** 1350 2370 3560 5020
- ☒ **B** 400 2650 3850 5110
- ☒ **C** 550 1060 4120 5440
- ☒ **D** 640 1180 1980 6000

(ii) Write an equation to show the decomposition of strontium carbonate on heating.

Include state symbols.

(2)

*(iii) A student compares the rate of thermal decomposition of some Group 1 and Group 2 carbonates using the apparatus shown.



The student tried to keep the temperature of heating approximately constant by using a Bunsen burner with the same settings. The time taken for the limewater to go cloudy is shown in the table.

Sample	Formula of carbonate	Time taken for limewater to turn cloudy / s
A	$CaCO_3$	40
B	$MgCO_3$	20
C	K_2CO_3	does not decompose
D	Li_2CO_3	35

Discuss how the student can use observations from the experiment, and knowledge of the cations present in the carbonates, to justify the relative rate of decomposition.

(6)

(Total for Question 5 = 10 marks)

6 Ammonium carbamate can be used to make urea, a fertilizer. Ammonium carbamate has the empirical formula $CH_6N_2O_2$.

(a) Ammonium carbamate contains 15.38% carbon, 7.69% hydrogen and 35.90% nitrogen by mass. The remainder is oxygen.

Show that the empirical formula of ammonium carbamate is $CH_6N_2O_2$.

(3)

(b) Ammonium carbamate is an ionic compound of formula $H_2NCOONH_4$.
It contains ammonium ions, NH_4^+, and carbamate ions, H_2NCOO^-.
When heated, ammonium carbamate decomposes to release ammonia and carbon dioxide.

(i) Write the balanced equation to show the decomposition of ammonium carbamate into ammonia and carbon dioxide. State symbols are not required.

(1)

(ii) What is the shape of the ammonia molecule, NH_3?

(1)

☒ **A** pyramidal

☒ **B** tetrahedral

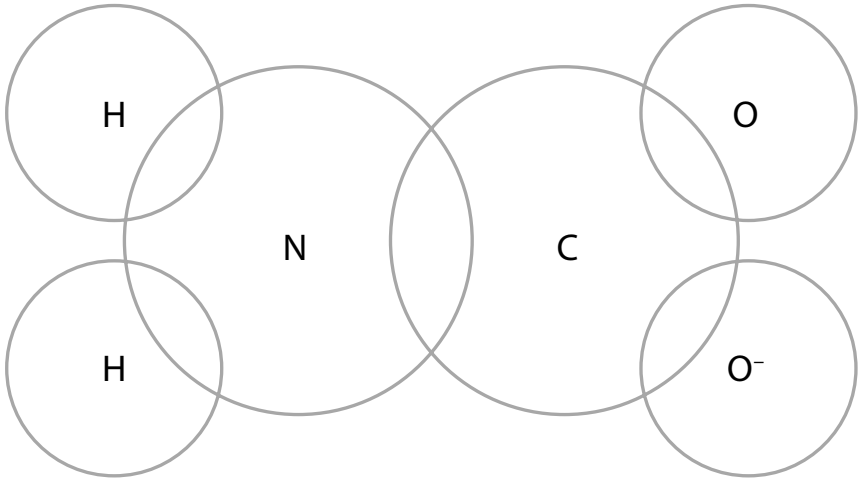
☒ **C** trigonal planar

☒ **D** V-shaped

(iii) Complete the dot-and-cross diagram for the carbamate ion, H_2NCOO^-.

Use dots (●) for the N electrons, crosses (×) for both H and C electrons, circles (o) for O electrons and the symbol Δ for the extra electron on the O^-.

(2)



(iv) Deduce the shape of the carbamate ion around the carbon atom. Justify your answer.

(3)

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(Total for Question 6 = 10 marks)

7 This question is about Group 7 and redox chemistry.

(a) Explain the trend in the boiling temperatures of the elements on descending Group 7, from fluorine to iodine.

(4)

(b) Which element in Group 7 has the highest first ionisation energy?

(1)

- ☒ **A** iodine
- ☒ **B** bromine
- ☒ **C** chlorine
- ☒ **D** fluorine

(c) When concentrated sulfuric acid, H_2SO_4, is added to solid sodium bromide, the acid reacts to form a mixture of products, including sulfur dioxide, SO_2, and bromine, Br_2.

The conversion of bromide ions to bromine is shown by the half-equation:

$$2Br^- \rightarrow Br_2 + 2e^-$$

In parts (c)(i) and (ii), state symbols are not required.

(i) Write a half-equation to show the formation of SO_2 from H_2SO_4.

(1)

(ii) Hence write an overall equation for the reaction of Br^- ions with H_2SO_4.

(1)

(iii) Deduce the role of Br^- ions in the reaction in (c)(ii).

(1)

(d) A student compares the reaction of solid sodium chloride and solid sodium iodide with concentrated sulfuric acid by adding 1 cm^3 of acid to separate samples of the solid halides in test tubes.

(i) The reaction between solid sodium chloride and concentrated sulfuric acid produces steamy fumes. Identify the product responsible for this observation.

(1)

.....

(ii) Solid sodium iodide also reacts with concentrated sulfuric acid. Steamy fumes are produced initially, but a second reaction then takes place.

Give an observation that you would expect the student to make in this second reaction, and write appropriate equations to show the overall reaction taking place.

State symbols are not required.

(3)

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(iii) Explain, in terms of the redox reactions occurring, why the solid halides form different products with concentrated sulfuric acid.

(2)

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(Total for Question 7 = 14 marks)

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8 A sample of trichloroethanoic acid was supplied to a laboratory by a chemical manufacturer. A technician at the laboratory was asked to check whether the percentage purity by mass of the acid was 99.9% as claimed on the label.

The technician used a titration method to determine the purity of the acid. The technician followed this method:

- The technician placed an empty glass bottle on a balance
- After zeroing the balance, the technician added a sample of trichloroethanoic acid to the bottle
- The technician recorded the balance reading, accurate to 1 d.p., as 6.2 g
- The technician transferred the acid to a beaker and dissolved the acid in a small volume of distilled water
- The technician poured this solution into a 250 cm^3 volumetric flask and made the solution level up to the mark with distilled water
- The technician filled a burette with the acid solution
- Using a pipette, 25.0 cm^3 of 0.130 mol dm^{-3} sodium hydroxide solution was transferred to a conical flask
- Several 25.0 cm^3 samples of the sodium hydroxide solution were titrated with the acid solution and the results were recorded.

Results

	Titration numbers				
	1	**2**	**3**	**4**	**5**
Burette reading (final)/cm^3	23.15	45.40	22.45	45.20	22.20
Burette reading (initial)/cm^3	0.00	23.15	0.15	22.50	0.00
Titre/cm^3					
Concordant titres (✓)					

Table 1

(a) Complete Table 1 and hence calculate the mean titre in cm^3.

(2)

(b) Trichloroethanoic acid has the formula CCl_3COOH.

The equation for the reaction with sodium hydroxide is:

$$CCl_3COOH(aq) + NaOH(aq) \rightarrow CCl_3COONa(aq) + H_2O(l)$$

(i) Calculate the concentration of trichloroethanoic acid in **g dm^{-3}**. Give your answer to one decimal place.

(3)

(ii) Show, using a calculation, that the percentage purity of trichloroethanoic acid is less than that claimed by the manufacturer.

(2)

(c) The uncertainties for the measurements made in this experiment were as follows.

Measurement	Uncertainty	Percentage error (%)
Each mass reading / g	±0.05	
Volumetric flask volume / cm^3	±0.5	0.200
Pipette volume / cm^3	±0.04	
Each burette reading / cm^3	±0.05	0.449

(i) Complete the table.

(1)

(ii) The total percentage error for the experiment can be estimated by adding together the four percentage errors.

Explain whether the manufacturer's claim that the acid is 99.9% pure is correct.

Use your answer to (b)(ii) and the total percentage error for this experiment.

(2)

(d) Identify **three** issues with the technician's method and for each issue identify an improvement.

(6)

(Total for Question 8 = 16 marks)

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

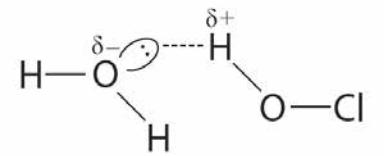
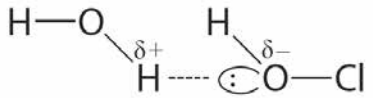
* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

CHEMISTRY AS PAPER 1 MARKSCHEME

Question Number	Answer	Additional Guidance	Mark
1(a)	An answer that makes reference to the following points: • **atoms** with the same number of protons (1) • with different numbers of neutrons (1)	Reject '**Elements** with the same…' Ignore references to the same number of electrons Ignore 'atoms of the same element that differ only in mass number'	**2**
1(b)	C		**1**
1(c)	• calculation of % ^{30}Si and substitution into expression showing sum of abundance x mass number ÷ total abundance (1) • evaluation of correct answer to 3 s.f. (1)	Example of calculation: $\frac{(92.2 \times 28) + (4.67 \times 29) + (3.13 \times 30)}{100}$ (= 28.1093) = 28.1 Correct answer with no working to 3.s.f scores 2 marks Ignore any units	**2**
1(d)	• calculation of number of moles of molecules present (1) • use of Avogadro number to convert to number of molecules (1)	Example of calculation: number of moles of molecules = 5.67 ÷ 170.1 = 0.03333... number of molecules = 0.03333...x 6.02 x 10^{23} = 2.01 x 10^{22} Allow 2 x 10^{22} Correct answer no working scores 2 marks	**2**

(Total for Question 1 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	An answer that makes reference to the following points: O (atom) • has more protons / has greater nuclear charge (1) • has smaller (atomic) radius (than C atom) (1)	Ignore references to shielding Allow just 'smaller' Allow reverse argument for carbon	**2**
2(b)	An explanation that makes reference to: (only carbon dioxide is non-polar) • because only carbon dioxide is symmetrical / linear (1) OR bond polarities are vectors / vector quantities • and therefore the bond polarities cancel (1)		**2**

Question Number	Answer	Additional Guidance	Mark
2(c)	 OR  • lone pair of electrons on O of one molecule (1) • δ+ symbol on one relevant H atom AND δ– symbol on one relevant O atom (1) If no representation of a hydrogen bond (by dashed line or similar), then only one of these marks can be awarded	No penalty for showing both possible hydrogen bonds	**2**

(Total for Question 2 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)	B		**1**
3(b)(i)	An explanation that makes reference to the following points: • use a fume cupboard (1) • as chlorine is toxic / poisonous (1)		**2**
3(b)(ii)	An explanation that makes reference to the following points: • cool the reaction vessel / surround the flask with cold water (1) • in order to prevent sublimation (of PCl_5) / to prevent the PCl_5 turning into a gas (1)		**2**
3(b)(iii)	• $PCl_3 + Cl_2 \rightarrow PCl_5$ (1)	Ignore state symbols, even if incorrect	**1**

Question Number	Answer	Additional Guidance	Mark
3(c)	• calculation of moles PCl_5 (= moles $POCl_3$) (1) • moles HCl = moles PCl_5 x 5 (1) • volume HCl = moles HCl x 24 dm^3 (1)	Allow ecf for steps in calculation, ignore significant figures in final answer except one significant figure Correct answer with no working scores 3 marks Example of calculation Moles PCl_5 = $\frac{4.17}{208.5}$ = 0.02(00) (mol) Moles HCl = 5 x 0.02(00) = 0.1(00) (mol) Volume HCl = 0.1 x 24 = 2.4 (dm^3)	**3**

(Total for Question 3 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)	D		**1**
4(b)	• calculation of moles AgCl (1) • total moles of Ag in 500 cm^3 (where moles Ag = moles AgCl) (1) • calculation of total mass of Ag (1) • evaluation of correct answer to 3.s.f using % by mass of Ag = $\frac{\text{Mass Ag}}{5.00} \times 100\%$ (1)	allow ecf for steps in calculation; including for final answer dependent on rounding in steps of the calculation. correct answer to 3.s.f with no working scores 4 marks Example of calculation Moles AgCl = $\frac{0.617}{143.4}$ = 0.00430.. (mol) Total moles Ag = $0.00430 \times \frac{500}{50.0}$ = 0.0430... Mass Ag = 0.0430 x 107.9 = 4.6425... = 4.64 (g) % by mass of Ag = $\frac{4.6425...}{5.00} \times 100\%$ = 92.9 %	**4**

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	An answer that makes reference to the following points: • (a reaction in which an) **element** (in a species) (1) • is simultaneously oxidised and reduced / for which the oxidation number both increases and decreases (in the same reaction) (1)	Reject 'atom'	**2**
4(c)(ii)	C		**1**

(Total for Question 4 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)	A		**1**
5(b)(i)	C		**1**
5(b)(ii)	$SrCO_3(s) \rightarrow SrO(s) + CO_2(g)$ • species (1) • state symbols (1)		**2**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*5(b)(iii)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table><tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr><tr><td>6</td><td>4</td></tr><tr><td>5–4</td><td>3</td></tr><tr><td>3–2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table></td><td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning.

For example, an answer with five indicative marking points, which is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

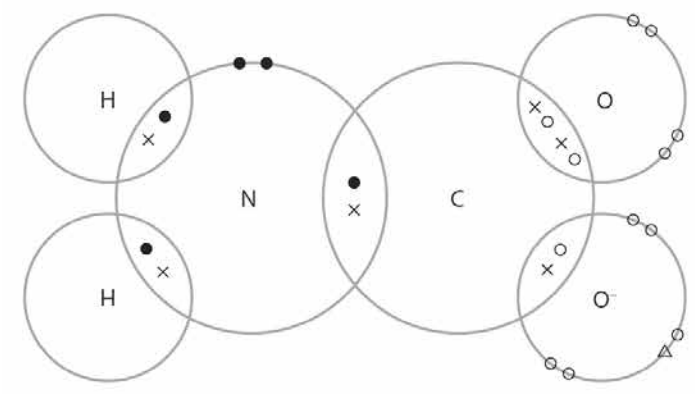
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*5(b)(iii) cont.</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr>
</table>
Indicative content:

Cloudiness / milkiness / formation of white ppte due to reaction between limewater and carbon dioxide
The shorter the time (for limewater to go cloudy), the faster the rate of decomposition
Rate of decomposition depends on metal ion size and charge / charge density
B faster than A as Mg^{2+} (radius) smaller than Ca^{2+}
B faster than D as charge density of Mg^{2+} greater than Li^{+} / higher charge of Mg^{2+} has more effect than smaller radius of Li^{+}
C does not decompose as K^{+} has (relatively) large radius and small charge
</td><td></td><td></td></tr>
</table>

(Total for Question 5 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)	• calculation of % by mass of oxygen (1) • evaluation of number of moles of C, H, N and O (1) • confirmation of ratio 1 : 6 : 2 : 2 (1)	Example of calculation (% by mass of) O = 41.03(%) C : H : N : O $\frac{15.38}{12.0} : \frac{7.69}{1.0} : \frac{35.90}{14.0} : \frac{41.03}{16.0}$ 1.28 : 7.69 : 2.56 : 2.56 $\frac{1.28}{1.28} : \frac{7.69}{1.28} : \frac{2.56}{1.28} : \frac{2.56}{1.28}$ = 1 : 6 : 2 : 2	**3**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	• $H_2NCOONH_4 \rightarrow 2NH_3 + CO_2$ (1)	Ignore state symbols, even if incorrect	**1**
6(b)(ii)	A		**1**
6(b)(iii)	 • all electron pairs correctly shown for C=O **and** C—O$^-$ (1) • correct electron pairs for C—N bond **and** the —NH_2 group **and** the lone pair on N (1)		**2**

Question Number	Answer	Additional Guidance	Mark
6(b)(iv)	• shape: trigonal planar (1) • justification: C=O treated as a single bond pair of electrons/(shape of ion) based on three bond pairs of electrons (around central C atom)/(shape of ion based on) three areas of electron density (around central C atom)/(shape of ion based on) three volumes of electron density (around central C atom) (1) electron pairs/electron regions repel to positions of maximum separation/minimum repulsion (1)	Reject 'atoms repel'/'bonds repel'/**Just** 'electrons repel'	**3**

(Total for Question 6 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	An explanation that makes reference to: • boiling temperatures **increase** from fluorine to iodine (1) • (as) more electrons per (X_2) molecule from fluorine to iodine (1) • (therefore the) strength of London forces increases from fluorine to iodine (1) Plus **one** from: • (so) more energy required to separate molecules (1) • (so) more energy required to break the intermolecular forces (1)	Allow molecules increase in size / mass from fluorine to iodine Allow 'more London forces' from fluorine to iodine Allow 'more heat' needed to separate molecules Allow more energy required to overcome the intermolecular attractions Reject 'more energy required to break covalent bonds' Allow reverse argument	**4**
7(b)	D		**1**
7(c)(i)	• $H_2SO_4 + 2H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ **or** • $SO_4^{2-} + 4H^+ + 2e^- \rightarrow SO_2 + 2H_2O$ (1)	Allow multiples Ignore state symbols, even if incorrect	**1**

Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	• $H_2SO_4 + 2H^+ + 2Br^- \rightarrow SO_2 + 2H_2O + Br_2$ **or** • $SO_4^{2-} + 4H^+ + 2Br^- \rightarrow SO_2 + 2H_2O + Br_2$ (1)	No ecf from (c)(i) Allow multiples Ignore state symbols, even if incorrect	**1**
7(c)(iii)	• reducing agent/electron donor/reduces sulfuric acid/reduces H_2SO_4 (1)		**1**
7(d)(i)	• hydrogen chloride / HCl (1)	Ignore state symbols	**1**
7(d)(ii)	Observation: • black solid / grey solid / purple vapour OR pungent gas OR yellow solid OR gas smelling of rotten eggs (1) Equations: • $NaI + H_2SO_4 \rightarrow NaHSO_4 + HI$ (1) • $2HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O$ OR $6HI + H_2SO_4 \rightarrow 3I_2 + S + 4H_2O$ OR $8HI + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$ (1) 2nd equation must match observation made	Allow purple solid Allow $2NaI + H_2SO_4 \rightarrow Na_2SO_4 + 2I$ Allow combinations of both equations for both marks e.g. $2NaI + 3H_2SO_4 \rightarrow 2NaHSO_4 + I_2 + SO_2 + 2H_2O$	**3**

Question Number	Answer	Additional Guidance	Mark
7(d)(iii)	An explanation that makes reference to the following points: • iodide ions are better reducing agents (than chloride ions) (1) • because iodide ions lose electrons more readily / electrons in iodide ions are less strongly held by the nucleus (1)	Allow HI is a better reducing agent (than HCl) Allow reverse argument	**2**

(Total for Question 7 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)	• correct calculation of all mean titres (23.15 and 22.25 and 22.30 and 22.70 and 22.20) (1) • concordant titres ticked (2, 3 and 5) **and** calculation of mean titre = 22.25 (cm^3) (1)	(i.e. those that agree within ±0.20 cm^3)	**2**
8(b)(i)	• calculation of number of moles trichloroethanoic acid (= number of moles of NaOH) (1) • rearrangement and evaluation of trichloroethanoic acid concentration in mol dm^{-3} (1) • evaluation of M_r of trichloroethanoic acid and conversion to concentration in g dm^{-3}, to 1 dp (1)	Allow ecf for steps in calculation; including for final answer dependent on rounding in steps of the calculation. Correct answer with no working to 1dp scores 3 marks Example of calculation moles acid = moles NaOH = $\frac{0.130 \times 25.0}{1000}$ = 3.25×10^{-3} / 0.00325 (mol) concentration of acid = $3.25 \times 10^{-3} \times \frac{1000}{22.25}$ = 0.146… mol dm^{-3} concentration acid in g dm^3 = 0.146… x 163.5 = 23.9 g dm^{-3}	**3**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	• calculation of number of grams of trichloroethanoic acid in 250 cm^3 (1) • calculation of % purity, showing it is < 99.9% (1) OR • conversion of measured mass into theoretical concentration in g dm^{-3} (1) • calculation of % purity, showing it is < 99.9% (1)	Example of calculation: mass acid in 250 cm^3 = 23.9 x $\frac{250}{1000}$ = 5.975 g purity = $\frac{5.975}{6.2}$ x 100% = 96.4 %, which is <99.9% OR theoretical concentration = 6.2 x $\frac{1000}{250}$ = 24.8 g dm^{-3} purity = $\frac{23.9}{24.8}$ x 100% = 96.4 %, which is < 99.9% Allow ecf on value in (b)(i)	**2**
8(c)(i)	• (each mass reading) = 1.61 % and (each pipette reading) = 0.160 % (1)	Example of calculation Each mass reading: (±) 2 x $\frac{0.05}{6.2}$ x 100% = 1.61% Each pipette volume: ± $\frac{0.04}{25.0}$ x 100% = 0.160%	**1**
8(c)(ii)	An explanation that makes reference to: • Total % error = 2.42% (1) • claim is not correct because 96.4 ± 2.42% is still lower than the manufacturer's value of 99.9% (1)	ecf on value obtained in (c)(i)	**2**

Question Number	Answer	Additional Guidance	Mark
8(d)	Maximum **three** marks for issue identified Maximum **three** marks for improvement identified which must be linked with associated issue identified • issue: mass of (solid) acid not accurately weighed out (1) • improvement: weigh mass of acid by difference/rinse out the weighing bottle/use a balance reading to 2 d.p./use a more precise balance (1) • issue: some acid will be left in the beaker/some acid will not be transferred to the volumetric flask (1) • improvement: rinse out the beaker (in which the solid acid was dissolved) and add the washings to the volumetric flask (1) • issue: insufficient mixing of the solution/concentration of the solution will not be uniform (1) • improvement: invert the volumetric flask (several times) (1) • issue: burette not rinsed (1) • improvement: burette should be rinsed with acid solution before use (1)	Reject use of a 'more **accurate**' balance Allow pipette not rinsed with sodium hydroxide	**6**

(Total for Question 8 = 16 mark)

Write your name here

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 ▶

S47552A

S 4 7 5 5 2 A 0 1 2 4

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)

(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

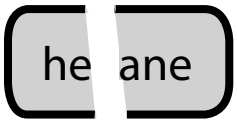
(d) Incomplete combustion of butane produces a mixture of products.

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:

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

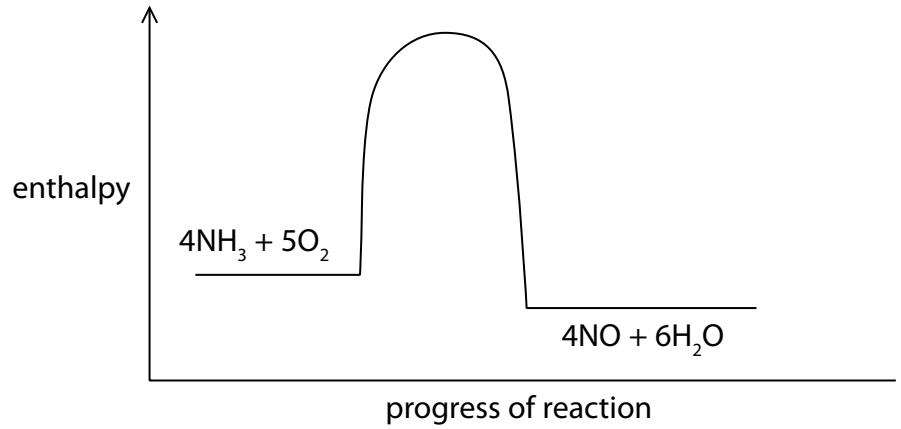
*(a) A manufacturer carries out this reaction at a temperature of 1200 K and a pressure of 10 atm. A scientist proposes that a temperature of 1000 K should be used at the same pressure.

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)

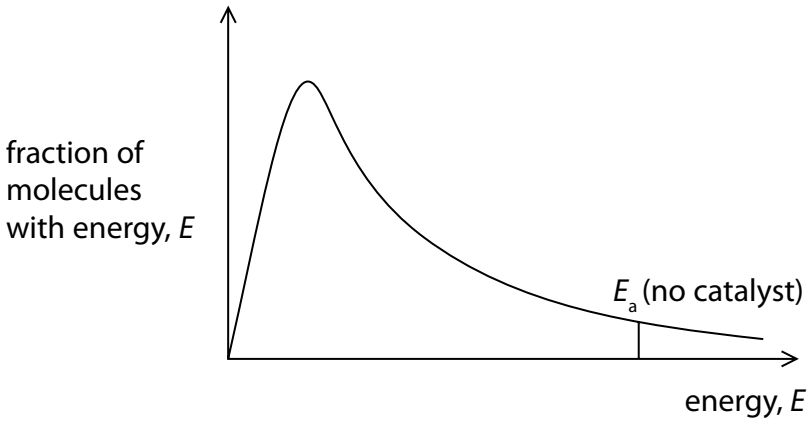
4 This question is about the thermal decomposition of ammonia.

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.

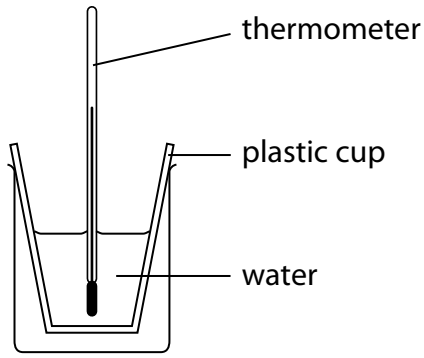
Bond	Bond enthalpy / kJ mol^{-1}
N≡N	+944
H–H	+436

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)

(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:

$CuSO_4.5H_2O(s) + aq \rightarrow CuSO_4(aq)$ $\quad \Delta_r H^{\ominus}_1 = +8.5 \text{ kJ mol}^{-1}$

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

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)

.....

.....

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

(2)

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

(3)

(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)

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

Give a reason why this name is incorrect.

(1)

(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)

.....

.....

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

(1)

.....

(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)

(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)

(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 $m/z = 43$

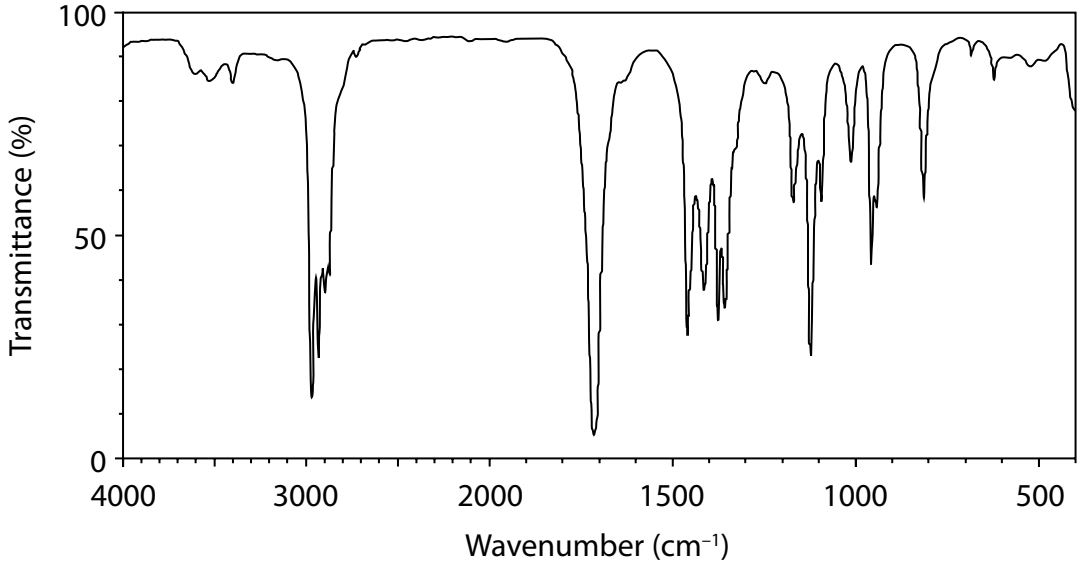
Deduce the structure of **T**. Justify your answer by identifying the structural formula of each fragment ion.

(3)

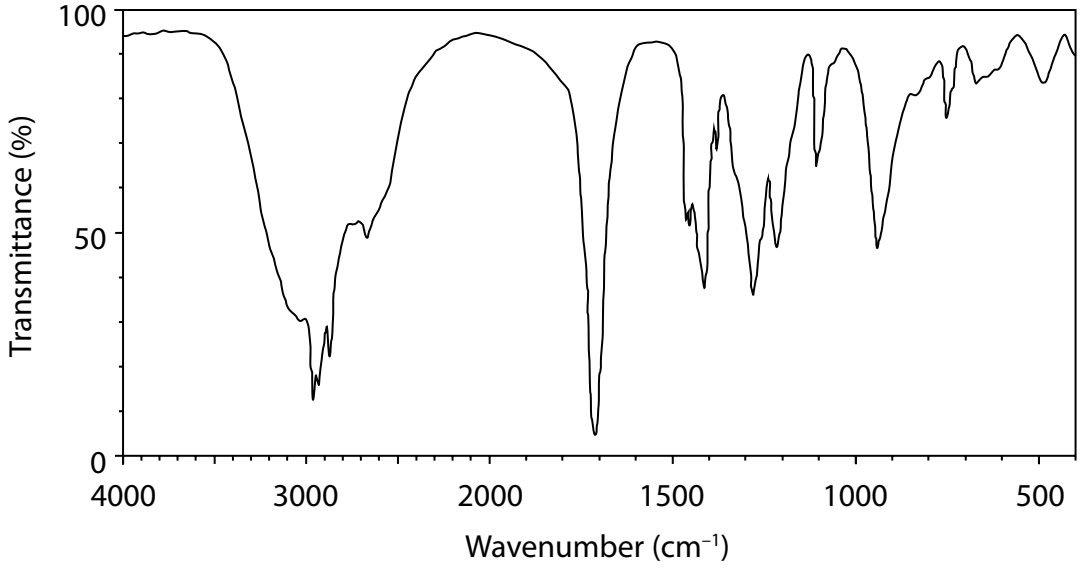
Some of the alcohols were heated with potassium dichromate(VI) and sulfuric acid. The organic compounds were separated from the reaction mixtures and purified.

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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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

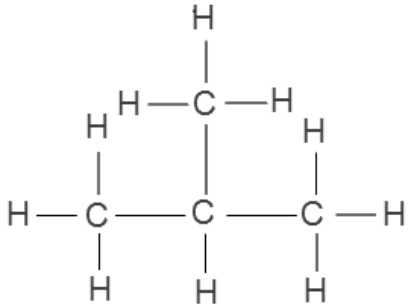
Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

CHEMISTRY AS PAPER 2 MARKSCHEME

Question Number	Answer	Additional Guidance	Mark
1(a)	 (1)	Every atom and every bond must be shown	**1**
1(b)	C_2H_5 (1)		**1**
1(c)	B		**1**
1(d)	C		**1**
1(e)	• re-arrangement of $pV = nRT$ equation (1) • conversion of volume and substitution (1) • evaluation of number of moles of alkane (1) • calculation of M_r, using number of moles and mass of alkane to identify it (1)	Correct answer, no working scores 4 marks Example of calculation $n = \frac{pV}{RT}$ $= \frac{100\,000 \times (83 \times 10^{-6})}{8.31 \times 425}$ = 0.00235… (moles) Mr = 0.235 / 0.00235… = 99.99 **or** 100 i.e. this is heptane	**4**

(Total for Question 1 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	An answer that makes reference to the following points: • (all equations) show oxygen/O_2 as a reactant/on the left (1) • (all) $\Delta_r H^{\ominus}$ values are negative /(all) reactions are exothermic (1)		**2**
2(b)	An answer that makes reference to the following points: • reaction 2 is not, because there is more than 1 product (1) • reaction 3 is not, because 2 moles of product are formed (1)	Accept because methane/CH_4 is not an element	**2**
2(c)	B		**1**
2(d)	D		**1**

(Total for Question 2 = 6 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*3(a)</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table></td><td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

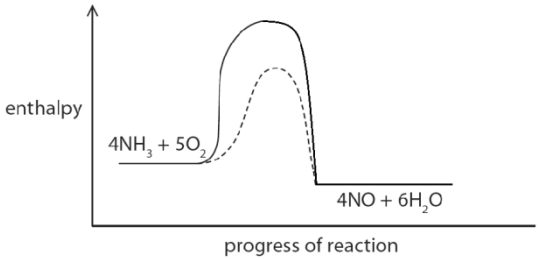
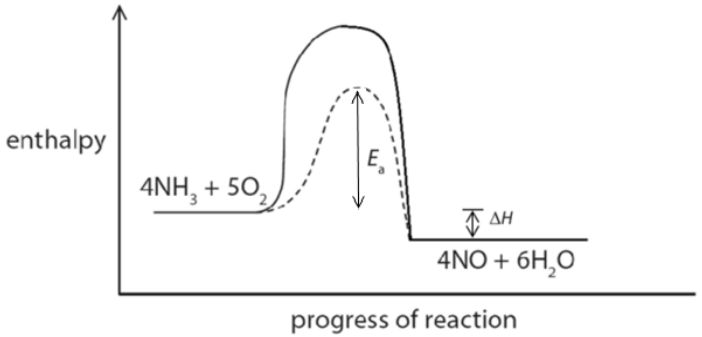
<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*3(a) cont.</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.

<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>

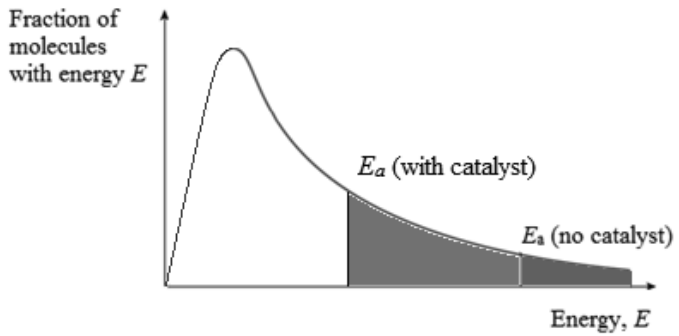
Indicative content:

• temperature decrease lowers the rate of the reaction
• because there are fewer molecules/particles with $E \geq E_a$
• <u>and</u> therefore there are fewer <u>successful</u> collisions <u>per second</u>
• temperature decrease increases the yield (of the product)
• because the (forward) reaction is exothermic
• lower rate and increased yield are opposing factors and it is not possible to tell which has greater effect on overall yield in a given time.</td><td>Accept slows down the reaction

Accept shifts the position of equilibrium to the right/in forward direction</td><td></td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	 • curve starting at reactants level, ending at products level, and peaking lower than original curve (1)		**1**
3(b)(ii)	 • $\Delta_r H$ shown as the approximately vertical distance between reactants and products (1) • E_a shown as the approximately vertical distance between reactants and peak of drawn curve for catalysed reaction (1)	ecf from candidate's curve	**2**
3(c)	$K_c = \frac{[NO(g)]^4[H_2O(g)]^6}{[NH_3(g)]^4[O_2(g)]^5}$ (1)	State symbols not essential	**1**

(Total for Question 3 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	 (1)	Line needs to be to the left of E_a (no catalyst) but to the right of the hump in the curve Shading not required but can be included and used in (a)(ii)	**1**
4(a)(ii)	An explanation that makes reference to the following points: • the area under the curve to the right of the activation energy represents the fraction of molecules that have $E \geq E_a$ (1) • the area under the curve to the right of E_a (with catalyst) is greater than the area under the curve to the right of E_a (no catalyst) (1) • (therefore) there are more successful collisions (per second per unit vol.) (1)	Accept description that involves shaded areas under the curve Accept more molecules have enough energy to react	**3**

Question Number	Answer		Additional Guidance	Mark
4(b)	• calculation of total bonds formed	(1)	Correct answer, no working scores 3 marks	**3**
	• re-arrangement of $\Delta_r H$ expression	(1)	Example of calculation	
	• evaluation of final answer	(1)	Σ(bonds formed) = E(N≡N) + 3E(H–H) = 944 + (3 x 436) = 2252 (kJ mol^{-1})	
			$\Delta_r H^{\ominus}$ = Σbonds broken – Σ(bonds formed), so Σ(bonds formed) = Σbonds broken – $\Delta_r H^{\ominus}$	
			6E(N–H) = 2252 – (-92) E(N–H) = (+) 391 (kJ mol^{-1})	
			Accept 390.7	

(Total for Question 4 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
5(a)	• calculation of temperature change and substitution into $Q = mc\Delta T$ (1) • conversion to kJ (1) • calculation of amount of copper(II) sulfate (1) • use of $\Delta H = -\frac{Q}{n}$ (1) • correct answer with sign and to 3. s.f (1)	Allow ecf for steps in calculation; including for final answer dependent on rounding in steps of the calculation. Correct answer with sign, to 3.s.f and no working scores 5 marks Mark consequentially on incorrect temperature change <u>Example of calculation</u> Q = 50.0 x 4.18 x 7.2 (J) = 1504.8 (J) Q = $\frac{1504.8}{1000}$ = 1.5048 (kJ) moles of copper(II) sulfate = 4.70 ÷ 159.6 = 0.029449 mol $\Delta H = -\frac{Q}{n} = -1.5048 \div 0.029449$ = (– 51.099) = – 51.1 (kJ mol^{-1})	**5**

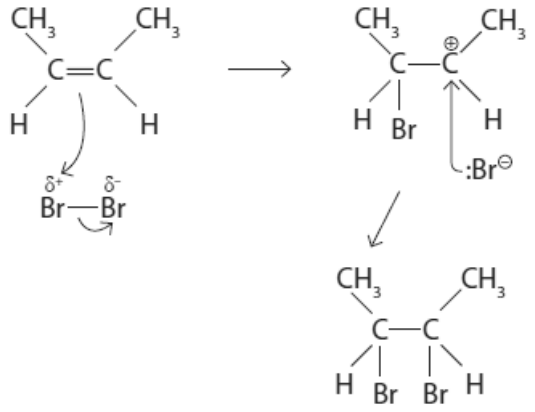
Question Number	Answer	Additional Guidance	Mark
5(b)	A description that makes reference to the following points: • record temperature at timed intervals (after adding the solid) (1) • plot these temperature values (on a graph) (1) • extrapolate the line of best fit to the time of adding the solid (1)		**3**
5(c)	• use of Hess cycle or expression e.g. $\Delta_r H = \Delta_r H_2 - \Delta_r H_1$ or $\Delta_r H = \Delta H_{solution}$(anhydrous) – $\Delta H_{solution}$(hydrated) (1) • correct final answer with sign (– 49.5 kJ mol^{-1}) (1)	Correct answer with sign and no working scores 2 marks	**2**
5(d)	An explanation that makes reference to the following points: • (the pale blue colour shows that) anhydrous copper (II) sulfate is partially hydrated (1) • therefore less anhydrous copper (II) sulfate reacts with water / some of the (blue) solid reacts endothermically (1) • therefore less thermal energy transferred / heat energy released during experiment **or** (experimental value) has a smaller negative value (1)		**3**

(Total for Question 5 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	• (pale) yellow (1)		**1**
6(a)(ii)	• conversion to seconds and use of $\frac{1}{\text{time in sec}}$ (1) • divide by lowest to get whole number ratio (1)	Example of calculation $\frac{1}{1250} : \frac{1}{555} : \frac{1}{5}$ or $8.00 \times 10^{-4} : 1.80 \times 10^{-3} : 0.20$ 1 : 2.25 : 250	**2**
6(a)(iii)	An explanation that makes reference to the following points: • the C–Cl bond is shorter than the C–I bond / the Cl atom is smaller than the I atom (1) • therefore, the C–Cl bond is stronger than the C–I bond (1) • therefore, the C–Cl bond needs more energy to break, and so the reaction is slower (1)	Allow reverse argument throughout	**3**

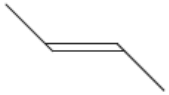
Question Number	Answer	Additional Guidance	Mark
6(b)(i)	D		**1**
6(b)(ii)	• **H**/ $(CH_3)_3$ CBr (1) • because C of C–Br is joined to 3 alkyl groups/joined to 3 carbon atoms (1)		**2**
6(b)(iii)	• number prefix used should be as low as possible / bromine atom is on the first carbon atom of the chain (1)		**1**

(Total for Question 6 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	(red-)brown to colourless (1)	Allow orange for red-brown Do not allow clear for colourless	**1**
7(b)(i)	electrophilic (addition) (1)		**1**
7(b)(ii)	 • partial charges on Br atoms (1) • curly arrow from C=C bond to (δ+) Br atom AND curly arrow from Br–Br bond to (δ–) Br atom (1) • structure of carbocation with + charge (1) • curly arrow from Br^- to C with + charge AND structure of 1, 2-dibromobutane product (1)	Accept cyclic bromonium ion with + charge shown in centre of ring	**4**

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	• calculation of % by mass of Br (1) • evaluation of number of moles of C, H, and Br (1) • final empirical formula based on whole number ratio (1)	Example of calculation %Br = 100 – 34.9 – 6.60 = 58.5% C $\frac{34.9}{12}$ = 2.91 H $\frac{6.60}{1}$ = 6.60 Br $\frac{58.5}{79.9}$ = 0.732 $\frac{2.91}{0.732}$ = 3.98 $\frac{6.60}{0.732}$ = 9.02 $\frac{0.732}{0.732}$ = 1 i.e. C_4H_9Br	**3**
7(c)(ii)	• 2–bromobutane (1)		**1**

Question Number	Answer	Additional Guidance	Mark
7(d)	An answer that includes at least one similarity and one difference to gain maximum marks: Similarities: • both involve the overlap of two (atomic) orbitals (each containing a single electron) (1) • both involve an electrostatic attraction between a <u>bonding</u> pair of electrons and two nuclei (1) Differences: • the σ bond represents electron density/electrons between the two carbon atoms/nuclei/end-on overlapping of atomic orbitals (1) • the π bond represents electron density/electrons above and below the σ bond/ sideways overlapping of orbitals (1) • the σ bond is formed by the overlap of a single lobe from one (atomic) orbital with a single lobe from the another (atomic) orbital (1) • the π bond is formed by the overlap of two lobes from one (atomic) orbital with two lobes of another (atomic) orbital (1)	Accept electrostatic attraction between a <u>shared</u> pair of electrons and two nuclei Accept end-to-end/head-on/axial overlapping	**3**

Question Number	Answer	Additional Guidance	Mark
7(e)	 (1)	Do not accept a structural or displayed formula.	**1**

(Total for Question 7 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)	• **P** $CH_3CH_2CH_2CH_2CH_2OH$ (1) • **Q** $(CH_3)_2CHCH(OH)CH_3$ (1) • **R** $(CH_3)_2C(OH)CH_2CH_3$ (1)	Accept displayed formulae	**3**
8(b)	• *m/z* = 45 is due to $CH_3CH(OH)^+$ (1) • *m/z* = 43 is due to $CH_3CH_2CH_2^+$ (1) • therefore the structure is $CH_3CH_2CH_2CH(OH)CH_3$ (1)	Penalise the lack of a plus sign once only $(CH_3)_2CHCH(OH)CH_3$ not allowed as it is Q	**3**
8(c)(i)	An answer that makes reference to the following points: • **Y** is a ketone because the spectrum contains an absorption for C=O (carbonyl group) 1700 – 1720 cm^{-1} (1) • **Z** is a carboxylic acid because the spectrum contains absorptions for C=O 1725-1700 cm^{-1} AND O–H (acids) 3300 – 2500 cm^{-1} (1)	Absence of bonds or absence of wavenumber ranges maximum 1 Allow values within the ranges	**2**

Question Number	Answer	Additional Guidance	Mark
8(c)(ii)	• calculation of mass of carbon from mass of CO_2 (1) • calculation of mass of hydrogen from mass of H_2O (1) • subtraction to find mass of O, and evaluation of number of moles of C, H and O (1) • confirm whole number ratio (1)	Example of calculation Mass of carbon = $(\frac{12}{44} \times 5.89) = 1.606$ g Mass of hydrogen = $(\frac{2}{18} \times 2.44) = 0.271$ g Mass of oxygen = 2.74 – 1.606 – 0.271 = 0.863 g C $\frac{1.606}{12} = 0.134$ H $\frac{0.271}{1} = 0.271$ O $\frac{0.863}{16} = 0.054$ Ratio = 2.48 : 5.02 : 1 = 5 : 10 : 2	**4**

(Total for Question 8 = 12 marks)

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