Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Friday 10 June 2016 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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3/6/6/3/5/1/

P 4 6 6 5 8 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 How many molecular ion peaks (parent ion peaks) are in the mass spectrum of 1,2-dibromoethane?

Assume the only isotopes present are ^{1}H, ^{12}C, ^{79}Br and ^{81}Br.

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 1 = 1 mark)

---

2 Four compounds that contribute to global warming are given below.

A Sulfur hexafluoride

B Dichlorodifluoromethane

C Methane

D Carbon dioxide

(a) Which of these molecules is polar?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Use this space for rough working. Anything you write in this space will gain no credit.

(b) Which of these compounds is emitted in the largest quantity by anthropogenic activity?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which of these compounds depletes the ozone layer?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) Which of these molecules has an octahedral structure?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 2 = 4 marks)

3 Which of the following is a tertiary alcohol?

☒ **A** 3-methylbutan-2-ol

☒ **B** 2-methylbutan-2-ol

☒ **C** 2-methylbutan-1-ol

☒ **D** 2,2-dimethylpropan-1-ol

(Total for Question 3 = 1 mark)

4 This question is about two isomeric alcohols and two isomeric carbonyl compounds.

Butan-1-ol, $CH_3CH_2CH_2CH_2OH$

Butan-2-ol, $CH_3CH_2CH(OH)CH_3$

Butanal, $CH_3CH_2CH_2CHO$

Butanone, $CH_3CH_2COCH_3$

(a) Which of these compounds would **not** produce a colour change when heated with acidified sodium dichromate(VI) solution?

(1)

☒ **A** Butan-1-ol

☒ **B** Butan-2-ol

☒ **C** Butanal

☒ **D** Butanone

(b) Which compound could give a peak at $m/e = 31$ in its mass spectrum?

(1)

☒ **A** Butan-1-ol

☒ **B** Butan-2-ol

☒ **C** Butanal

☒ **D** Butanone

(c) Which compound could **not** give a peak at $m/e = 43$ in its mass spectrum?

(1)

☒ **A** Butan-1-ol

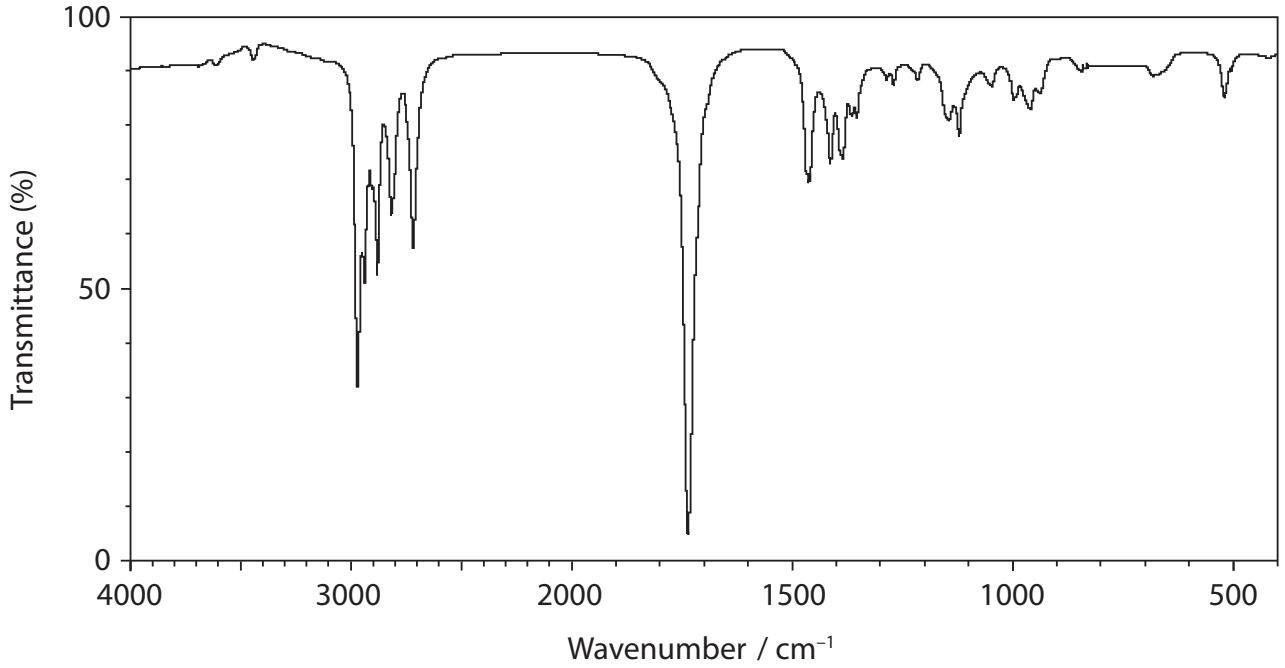
☒ **B** Butan-2-ol

☒ **C** Butanal

☒ **D** Butanone

Use this space for rough working. Anything you write in this space will gain no credit.

(d) The infrared spectrum of one of these compounds is given below.



Use the infrared absorptions, in wavenumbers, to identify the compound.

Bond	Wavenumber range / cm^{-1}
O—H (alcohol)	3750 – 3200
C—H (alkane)	2962 – 2853
C—H (aldehyde)	2900 – 2820 and 2775 – 2700
C=O (aldehyde or ketone)	1740 – 1680

The compound with this IR spectrum is

(1)

☒ **A** butan-1-ol.

☒ **B** butan-2-ol.

☒ **C** butanal.

☒ **D** butanone.

(Total for Question 4 = 4 marks)

5 A Maxwell-Boltzmann curve shows the distribution of molecular energies in a reaction system. When the temperature in this system is **increased**, the peak is

☒ **A** higher and further to the right.

☒ **B** higher and further to the left.

☒ **C** lower and further to the right.

☒ **D** lower and further to the left.

(Total for Question 5 = 1 mark)

6 This question is about the equilibrium reaction between hydrogen and carbon dioxide.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g) \qquad \Delta H^{\ominus} = +40 \text{ kJ mol}^{-1}$$

What effect would the following changes have on the rate of reaction and the yield of carbon monoxide?

(a) **Increase** in temperature.

(1)

	Rate	Yield of CO
☒ **A**	increase	increase
☒ **B**	increase	decrease
☒ **C**	increase	no change
☒ **D**	no change	decrease

(b) **Increase** in pressure.

(1)

	Rate	Yield of CO
☒ **A**	increase	increase
☒ **B**	increase	decrease
☒ **C**	increase	no change
☒ **D**	no change	no change

(Total for Question 6 = 2 marks)

7 Which is the equation for the reaction when steam passes over strongly heated magnesium?

☒ **A** $Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$

☒ **B** $Mg(s) + 2H_2O(g) \rightarrow Mg(OH)_2(s) + H_2(g)$

☒ **C** $Mg(s) + H_2O(l) \rightarrow MgO(s) + H_2(g)$

☒ **D** $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

(Total for Question 7 = 1 mark)

8 What happens to the solubilities of the hydroxides and sulfates as Group 2 is descended?

	Solubility of hydroxides	Solubility of sulfates
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

(Total for Question 8 = 1 mark)

9 Which one of the following substances forms when a few drops of concentrated sulfuric acid is added to sodium chloride?

☒ **A** H_2O

☒ **B** Cl_2

☒ **C** $NaHSO_4$

☒ **D** SO_2

(Total for Question 9 = 1 mark)

Use this space for rough working. Anything you write in this space will gain no credit.

10 25.00 cm^3 of 1.00 mol dm^{-3} sulfuric acid is fully neutralized by 50.00 cm^3 of 1.00 mol dm^{-3} sodium hydroxide.

(a) What is the concentration of sodium sulfate solution produced by the reaction, in mol dm^{-3}?

(1)

☒ **A** 1.00

☒ **B** 0.67

☒ **C** 0.50

☒ **D** 0.33

(b) The volumes are measured using burettes, with each burette reading having an uncertainty of ±0.05 cm^3.

The percentage error in measuring the 25.00 cm^3 of the acid is

(1)

☒ **A** ±0.05%

☒ **B** ±0.10%

☒ **C** ±0.20%

☒ **D** ±0.40%

(Total for Question 10 = 2 marks)

11 Pentan-1-ol is less soluble than ethanol in water. The best explanation for this is that

☒ **A** pentan-1-ol molecules cannot form hydrogen bonds with water molecules, but ethanol molecules can.

☒ **B** London forces are stronger between pentan-1-ol molecules than between ethanol molecules.

☒ **C** carbon-carbon bonds are stronger in pentan-1-ol than in ethanol.

☒ **D** permanent dipole forces are stronger in pentan-1-ol than in ethanol.

(Total for Question 11 = 1 mark)

Use this space for rough working. Anything you write in this space will gain no credit.

12 Along the series of the Group 5 hydrides (NH_3, PH_3 and AsH_3), the boiling temperatures

- ☒ **A** decrease.
- ☒ **B** decrease then increase.
- ☒ **C** increase.
- ☒ **D** increase then decrease.

(Total for Question 12 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

13 This question is about the fluorides BF_3, NF_3, OF_2 and O_2F_2.

(a) (i) For BF_3, name the shape of the molecule and give the FBF bond angle.

(2)

Shape .....

Bond angle .....

*(ii) For the NF_3 molecule, draw the shape you would expect and suggest the FNF bond angle. Explain why the molecule has this shape and bond angle.

(4)

Shape

Bond angle .....

Explanation .....

.....

.....

.....

(iii) Draw a diagram to show the bonding in the single product of the reaction between BF_3 and NF_3.

Identify the type of bond that forms between these two molecules.

(2)

.....

(b) (i) What is the oxidation number of oxygen in OF_2?

(1)

.....

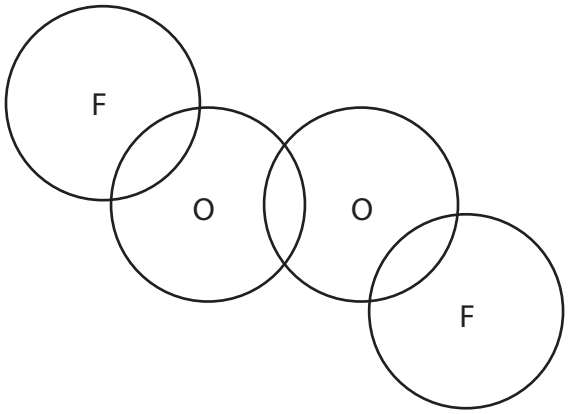
(ii) When water reacts with OF_2, oxygen is one of the products. Suggest an equation for this reaction.

State symbols are not required.

(1)

(c) Complete the diagram with dots and crosses to show the outer shell electrons in the O_2F_2 molecule.

(1)



(Total for Question 13 = 11 marks)

14 (a) The rates of hydrolysis of three bromoalkanes are compared.

2 cm^3 of ethanol is added to three test tubes, **A**, **B** and **C**.

Three drops of bromoalkane are added to each of these three test tubes.

1-bromobutane is added to test tube **A**.
2-bromobutane is added to test tube **B**.
2-bromo-2-methylpropane is added to test tube **C**.

2 cm^3 of hot aqueous silver nitrate solution is added to each test tube.

(i) Explain why ethanol is added to each test tube.

(1)

.....

.....

(ii) Complete the general equation for the hydrolysis of these bromoalkanes.

State symbols are not required.

(1)

$C_4H_9Br + H_2O \rightarrow$

(iii) Eventually a precipitate is formed in each test tube. Give the colour of the precipitate formed and write the ionic equation, with state symbols, for its formation.

(2)

Colour .....

Ionic Equation

(iv) Identify the reagent you could add to dissolve the precipitate.

(1)

.....

(v) Give the order in which the precipitates form in the test tubes **A**, **B** and **C**, giving the fastest first.

(1)

.....

*(vi) State how the rates of hydrolysis depend on the structure of the bromoalkane. Suggest a reason for this difference. You are not required to give detailed mechanisms for the reactions.

(2)

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(b) (i) When 1-bromobutane reacts with an alcoholic solution of sodium hydroxide, a different reaction occurs.

Draw a fully labelled diagram to show the apparatus needed for carrying out this reaction in the laboratory and collecting the gaseous organic product.

(2)

(ii) Name the organic product for this reaction and draw its **skeletal** formula.

(2)

Name .....

Skeletal formula

(c) 1-bromobutane reacts with alcoholic ammonia when heated under pressure.

(i) State the type and mechanism of this reaction.

(2)

Type .....

Mechanism .....

(ii) Name the organic product of this reaction.

(1)

.....

(Total for Question 14 = 15 marks)

15 Hydrated magnesium nitrate, $Mg(NO_3)_2.6H_2O$, is heated in a boiling tube and the following observations are made.

Stage 1 The white solid forms a clear, colourless solution.

Stage 2 Condensation forms around the mouth of the boiling tube and a white solid starts to form at the bottom of the tube.

Stage 3 As the heating continues, the colourless solution disappears leaving a white solid.

Stage 4 The white solid melts.

Stage 5 A brown gas forms.

Stage 6 A glowing splint reignites when it is placed in the boiling tube.

Stage 7 A white solid is left in the boiling tube.

(a) Explain what is happening in stages 1 and 2.

(3)

(b) (i) Identify the products formed in stages 5, 6 and 7.

(3)

Stage 5 .....

Stage 6 .....

Stage 7 .....

(ii) Write the equation for the complete thermal decomposition of hydrated magnesium nitrate, $Mg(NO_3)_2.6H_2O$.

State symbols are not required.

(2)

(c) The chlorides of magnesium and calcium can be distinguished from each other by carrying out a flame test.

(i) Describe what you would see in each test.

(2)

Magnesium chloride .....

Calcium chloride .....

*(ii) Explain how flame colours arise in a flame test.

(3)

.....

.....

.....

.....

.....

.....

(iii) Suggest why the observations of the flame tests for magnesium chloride and calcium chloride are different.

(2)

.....

.....

.....

.....

.....

(Total for Question 15 = 15 marks)

TOTAL FOR SECTION B = 41 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

16 Olive oil is an important edible oil. In many European countries, it is used as an alternative to butter for spreading on bread.

A useful method of comparing fats and oils is to measure their iodine values. An iodine value is the amount of iodine in grams that reacts with 100 g of a fat or oil. This measures the degree of unsaturation of the fat or oil.

The iodine value of olive oil can be determined in the following way.

Add 0.200 g of olive oil to a 250 cm^3 conical flask.

Add 10 cm^3 of solvent to dissolve the oil.

Add 10.0 cm^3 of a solution of iodine monochloride, called Wijs solution.

Stopper the flask and allow to stand in the dark for half an hour.

Add 15 cm^3 of 10% potassium iodide solution and 100 cm^3 of water and shake the mixture.

Titrate the liberated iodine with 0.100 mol dm^{-3} sodium thiosulfate solution. This is the sample titre.

Carry out a blank titration using 10 cm^3 of solvent, 10.0 cm^3 of Wijs solution, 15 cm^3 of 10% potassium iodide solution and 100 cm^3 of water.

(a) For many years, 1,1,1-trichloroethane was used as the solvent for this reaction.

(i) Draw the **displayed** formula for 1,1,1-trichloroethane.

(1)

(ii) Explain why 1,1,1-trichloroethane has a higher boiling temperature than hexane.

(2)

(iii) Suggest why the solvent 1,1,1-trichloroethane is no longer used.

(1)

(b) (i) Iodine monochloride adds more readily than iodine to carbon-carbon double bonds. Using your knowledge of electrophilic addition, suggest why this is so.

(1)

(ii) Complete the formula of the product formed when iodine monochloride, ICl, reacts with oleic acid, $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$, the most abundant unsaturated compound in olive oil.

(1)

$$CH_3(CH_2)_7{-}C{-}C{-}(CH_2)_7COOH$$

(iii) Suggest why the mixture must be kept in the dark.

(1)

(iv) Give the oxidation numbers of iodine in iodine monochloride, iodide ions and iodine.

Write the ionic equation for the reaction between iodide ions and iodine monochloride. State symbols are not required.

(2)

Oxidation number of iodine in

Iodine monochloride .....

Iodide ion .....

Iodine .....

Ionic equation for this reaction

(c) Suggest a suitable indicator for the titration. Give the colour change of the solution at the end point.

(2)

Indicator .....

Colour change from ..... to .....

(d) In the blank titration, 20.0 cm^3 of sodium thiosulfate solution reacted with 10.0 cm^3 of Wijs solution.

(i) Calculate the number of moles of 0.100 mol dm^{-3} sodium thiosulfate that reacted with the **blank** titre.

(1)

(ii) Complete the ionic equation for the reaction between iodine and thiosulfate ions. Include state symbols.

(1)

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow$

(iii) Calculate the number of moles of iodine, I_2, that reacted with the thiosulfate solution in the blank titration.

(1)

(iv) Using your answers to (b)(iv) and (d)(iii), write down the corresponding number of moles of iodine monochloride solution in 10 cm^3 of Wijs solution.

(1)

(v) The number of moles of iodine monochloride left after reacting the Wijs solution with the olive oil sample, calculated from the sample titre, is 3.65×10^{-4} mol.

Use this, and your answer to (d)(iv), to calculate the amount of iodine monochloride that reacted with the sample.

(1)

(vi) Your answer to (d)(v) is equal to the number of moles of iodine that would have reacted with 0.200 g of olive oil.

Calculate the number of moles of iodine that would have reacted with 100 g of olive oil.

(1)

(vii) Calculate the mass of iodine, I_2, that would have reacted with 100 g of olive oil, which is the iodine value for the olive oil.

(1)

(e) Butter contains a smaller percentage of unsaturated molecules than olive oil.

Would the titre value and iodine value for butter be higher, lower or about the same as the values for olive oil?

(1)

Sample titre .....

Iodine value .....

(Total for Question 16 = 19 marks)

TOTAL FOR SECTION C = 19 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: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											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