Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Monday 18 January 2016 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

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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6/6/6/6/

P 4 6 9 3 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 Which of these molecules is polar?

☒ **A** CO_2

☒ **B** NH_3

☒ **C** CCl_4

☒ **D** CH_4

(Total for Question 1 = 1 mark)

2 Which of these species has bond angles equal to 90°?

☒ **A** BeF_4^{2-}

☒ **B** $SiCl_4$

☒ **C** NH_4^+

☒ **D** SF_6

(Total for Question 2 = 1 mark)

3 Which of these species does **not** have a trigonal pyramidal shape?

☒ **A** BF_3

☒ **B** NH_3

☒ **C** H_3O^+

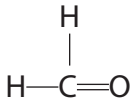
☒ **D** PH_3

(Total for Question 3 = 1 mark)

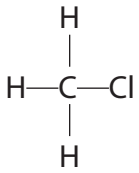
Use this space for any rough working. Anything you write in this space will gain no credit.

4 Which of the following molecules has the greatest number of lone pairs of electrons?

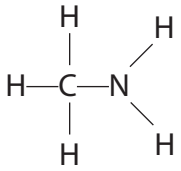
☒ **A**



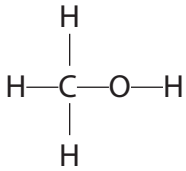
☒ **B**



☒ **C**

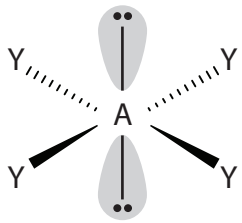


☒ **D**



(Total for Question 4 = 1 mark)

5 This diagram represents a square planar structure:



Which of these species has this square planar shape?

☒ **A** SF_4

☒ **B** NH_4^+

☒ **C** XeF_4

☒ **D** AlH_4^-

(Total for Question 5 = 1 mark)

6 Which of the following compounds has hydrogen bonding in the **liquid** state?

☒ **A** Hydrogen bromide, HBr

☒ **B** Hydrogen sulfide, H_2S

☒ **C** Silane, SiH_4

☒ **D** Ammonia, NH_3

(Total for Question 6 = 1 mark)

7 Which of the following elements has the greatest attraction for bond pairs of electrons in a covalent bond?

☒ **A** Beryllium

☒ **B** Boron

☒ **C** Bromine

☒ **D** Chlorine

(Total for Question 7 = 1 mark)

8 In a molecule of hydrogen, the two hydrogen atoms are held together by

☒ **A** a hydrogen bond.

☒ **B** a polar covalent bond.

☒ **C** a non-polar covalent bond.

☒ **D** London forces.

(Total for Question 8 = 1 mark)

9 Which of these metal salts gives a lilac colour during a flame test?

☒ **A** Sodium chloride

☒ **B** Potassium chloride

☒ **C** Barium chloride

☒ **D** Magnesium chloride

(Total for Question 9 = 1 mark)

10 A volume of 100 cm^3 of a solution of 0.500 mol dm^{-3} silver nitrate, $AgNO_3(aq)$, is reacted completely with excess calcium chloride solution, $CaCl_2(aq)$.

The maximum mass of precipitate that can form is

☒ **A** 7.17 g

☒ **B** 8.50 g

☒ **C** 8.95 g

☒ **D** 14.3 g

(Total for Question 10 = 1 mark)

11 What volume of 0.200 mol dm^{-3} potassium sulfate solution is required to make, by dilution with water, 1.00 dm^3 of a solution with a **potassium** ion concentration of 0.100 mol dm^{-3}?

☒ **A** 100 cm^3

☒ **B** 250 cm^3

☒ **C** 400 cm^3

☒ **D** 500 cm^3

(Total for Question 11 = 1 mark)

12 What is the volume of dilute sulfuric acid, concentration 0.0250 mol dm^{-3}, required to neutralize 20.0 cm^3 aqueous sodium hydroxide, concentration 0.0100 mol dm^{-3}?

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

☒ **A** 4.00 cm^3

☒ **B** 8.00 cm^3

☒ **C** 16.0 cm^3

☒ **D** 40.0 cm^3

(Total for Question 12 = 1 mark)

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

13 The chlorate(I) ion, $ClO^-(aq)$, is formed when chlorine dissolves in water.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + Cl^-(aq) + ClO^-(aq)$$

The concentration of chlorate(I) ions could be increased by the addition of

☒ **A** solid potassium hydroxide.

☒ **B** concentrated hydrochloric acid.

☒ **C** solid sodium chloride.

☒ **D** solid potassium sulfate.

(Total for Question 13 = 1 mark)

14 When solutions of iodine are titrated with aqueous sodium thiosulfate solution, $Na_2S_2O_3(aq)$, the thiosulfate ions are oxidized to

☒ **A** $S_2O_4^{2-}$

☒ **B** $S_2O_6^{2-}$

☒ **C** $S_2O_8^{2-}$

☒ **D** $S_4O_6^{2-}$

(Total for Question 14 = 1 mark)

15 Which trends are correct as Group 2 is descended?

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

(Total for Question 15 = 1 mark)

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

16 Which is a tertiary halogenoalkane?

☒ **A** $CHBr_3$

☒ **B** $(CH_2Br)_3CH$

☒ **C** $(CH_3)_3CBr$

☒ **D** $BrCH_2C(CH_3)_3$

(Total for Question 16 = 1 mark)

17 Propene can be formed by heating 1-bromopropane with alcoholic potassium hydroxide solution.

This reaction is an example of

☒ **A** reduction.

☒ **B** hydrolysis.

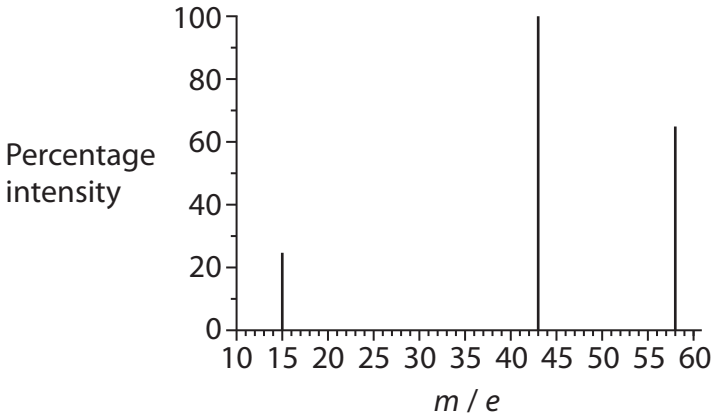
☒ **C** elimination.

☒ **D** substitution.

(Total for Question 17 = 1 mark)

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

18 A simplified mass spectrum of an organic compound is shown in the diagram.



Which of the following compounds produces this spectrum?

☒ **A** Propane

☒ **B** Propan-1-ol

☒ **C** Propan-2-ol

☒ **D** Propanone

(Total for Question 18 = 1 mark)

19 A compound with empirical formula C_3H_6O could be

☒ **A** hexane-1,2-diol.

☒ **B** hexan-2-ol.

☒ **C** hexan-2-one.

☒ **D** hexanoic acid.

(Total for Question 19 = 1 mark)

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

20 Equal amounts of 1-chlorobutane and 1-iodobutane are warmed with aqueous silver nitrate in the presence of ethanol.

Why does 1-chlorobutane react more slowly?

☒ **A** The C—Cl bond is more polar than the C—I bond.

☒ **B** The C—Cl bond is stronger than the C—I bond.

☒ **C** The C—I bond is more polar than the C—Cl bond.

☒ **D** The C—I bond is stronger than the C—Cl bond.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

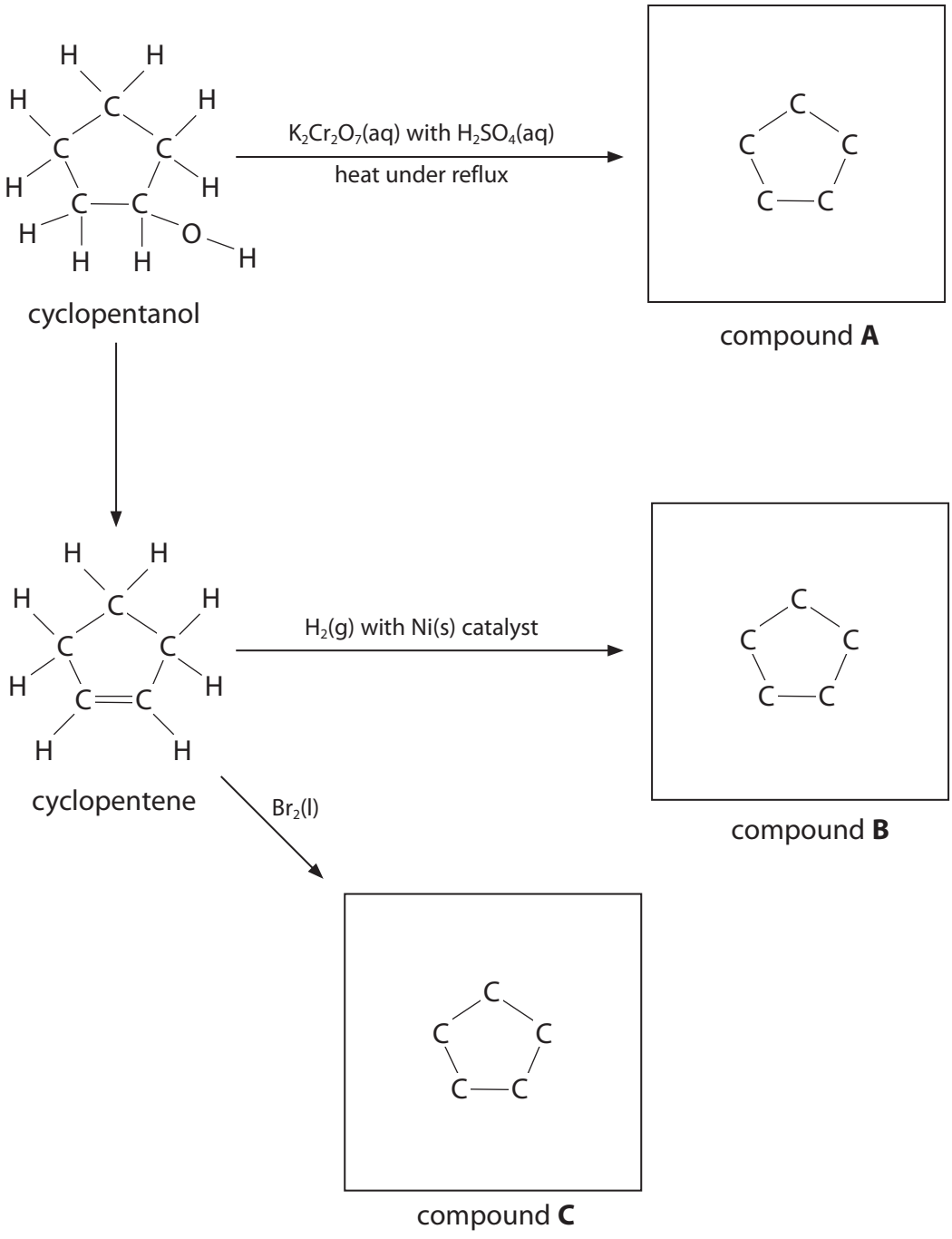
Answer ALL the questions. Write your answers in the spaces provided.

21 Cyclopentene is a cyclic alkene and cyclopentanol is a cyclic alcohol.

(a) Some reactions involving cyclopentene and cyclopentanol are shown in the flowchart.

Complete the displayed formulae in the boxes to show the compounds **A**, **B** and **C**, which are the **organic** products of the reactions.

(3)

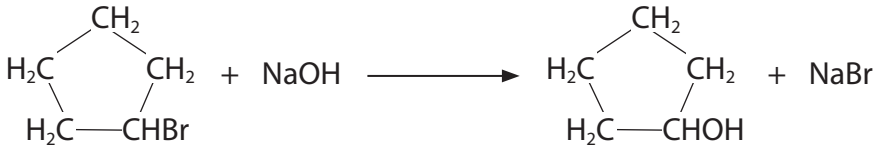


(b) Give the colour change that would be observed in the reaction between liquid bromine, Br_2, and excess cyclopentene.

(1)

From ..... to .....

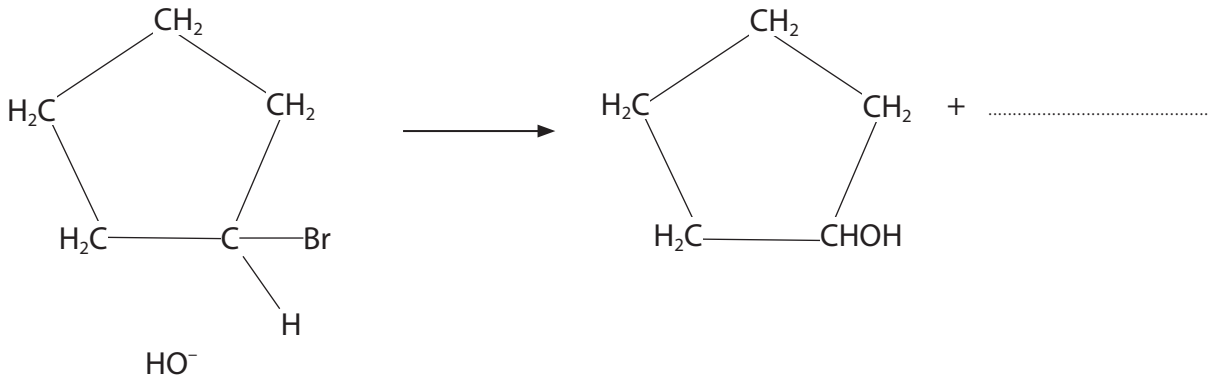
(c) Bromocyclopentane reacts when heated with aqueous sodium hydroxide solution, according to the following equation.



(i) Complete the mechanism for this reaction on the following diagram.

Use 'curly arrows' where necessary and show any relevant dipoles.

(3)



(ii) Classify both the type of reaction and mechanism shown in (c)(i).

(2)

Type of reaction: .....

Mechanism: .....

(iii) What type of bond fission occurs in this reaction?

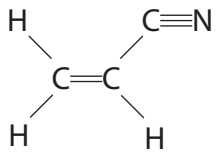
(1)

.....

(Total for Question 21 = 10 marks)

22 Poly(propenenitrile) is used in the manufacture of acrylic fibres for clothes.
Poly(propenenitrile) is an addition polymer made from propenenitrile.

The structure of propenenitrile is shown.



(a) Give a balanced equation, using displayed formulae, to show the formation of poly(propenenitrile) from propenenitrile.

(3)

(b) Why does the reaction in (a) have an atom economy of 100%?

(1)

.....

.....

*(c) Propenenitrile is manufactured from propene, C_3H_6, as shown in the following equation.

$$C_3H_6(g) + NH_3(g) + 1\frac{1}{2}O_2(g) \rightleftharpoons CH_2CHCN(g) + 3H_2O(g) \qquad \Delta H = -550 \text{ kJ mol}^{-1}$$

The process is carried out at a temperature of 450°C and a pressure of 2.5 atm, in the presence of a suitable catalyst.

State and explain the effect on the position of equilibrium when each of the following changes is made to these reaction conditions.

(i) The temperature is increased.

(2)

(ii) The pressure is increased.

(2)

*(d) Chemical manufacturers also use reaction conditions to control the rates of chemical reactions.

(i) The curves in (d)(ii) and (d)(iii) show the distribution of molecular energies at a temperature, T_1.

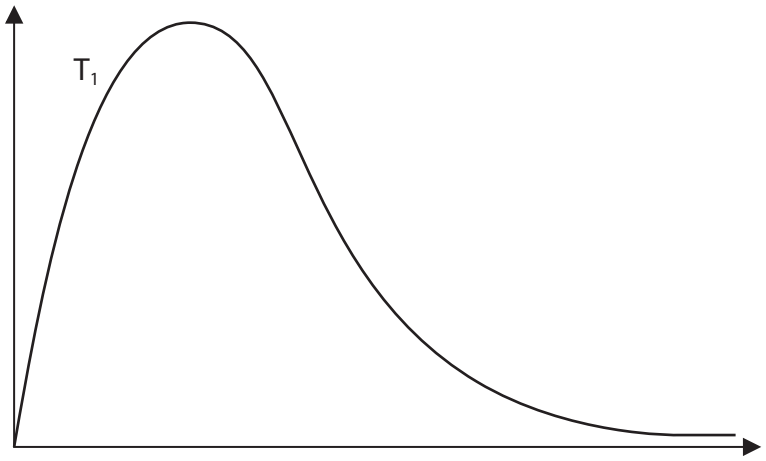
Label the axes on the diagrams in (d)(ii) and (d)(iii).

(1)

(ii) On the diagram below, draw a curve to show the distribution of molecular energies at a higher temperature, T_2.

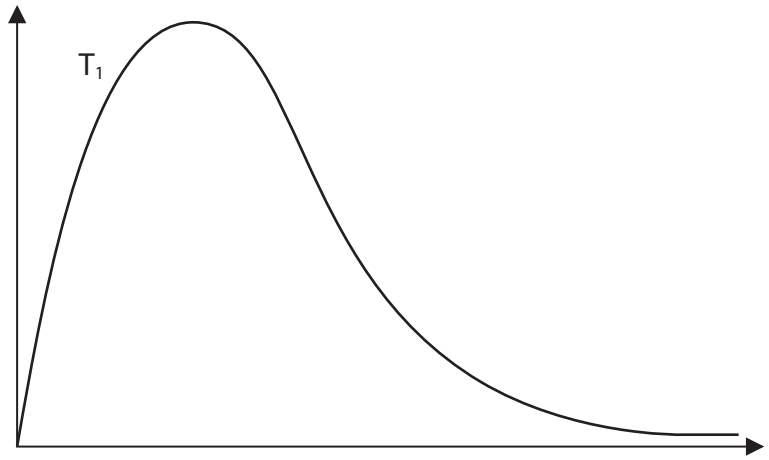
Use your diagram, with further labelling as necessary, to explain why the rate of a chemical reaction increases when the temperature is increased.

(3)



(iii) Use the diagram below, with further labelling as necessary, to explain why the rate of a chemical reaction increases when a catalyst is added at temperature T_1.

(2)



(Total for Question 22 = 14 marks)

23 Solid calcium hydroxide, $Ca(OH)_2$, is also known as 'slaked lime'. Over one million tonnes of slaked lime are produced annually in the UK.

(a) Limewater is an aqueous solution of calcium hydroxide, $Ca(OH)_2$. Limewater is used in the laboratory as a test for carbon dioxide.

(i) Suggest a value for the pH of limewater.

(1)

.....

(ii) Write an equation, including state symbols, for the reaction that takes place when limewater is used to confirm the presence of carbon dioxide.

(2)

(b) An aqueous solution of calcium hydroxide contains calcium ions and hydroxide ions.

(i) How many moles of **ions** are there in one mole of calcium hydroxide?

(1)

.....

(ii) How many moles of **electrons** are there in one mole of hydroxide ions?

(1)

.....

(c) 'Slaked lime' (solid calcium hydroxide) can be prepared from calcium carbonate, $CaCO_3$, in two stages.

Outline how this preparation would be carried out in the laboratory. Include an equation for each stage. State symbols are not required. You do **not** need to include any details of apparatus in your answer, but you should mention any essential conditions.

(4)

(d) Coal-fired power stations produce sulfur dioxide, SO_2. This pollutant gas is toxic and causes acid rain.

(i) The sulfur dioxide combines with water and oxygen in the atmosphere to produce sulfuric acid, H_2SO_4.

Write a balanced equation, including state symbols, for this overall reaction.

(2)

(ii) One way to lower the amount of sulfur dioxide emissions is to pass the waste gas through a fine powder of calcium oxide, CaO(s).

Explain why calcium oxide would be expected to react with sulfur dioxide.

(1)

(iii) State **one** other environmental problem associated with coal-fired power stations. Identify the substance which causes this problem.

(2)

.....

.....

.....

.....

(Total for Question 23 = 14 marks)

TOTAL FOR SECTION B = 38 MARKS

SECTION C

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

24 This question is about some aspects of the chemistry of iodine and its compounds.

In industry, the main source of iodine is sodium iodate(V), $NaIO_3$, which occurs in deposits found in Chile.

In the human body, iodide ions, I^-, are needed for the thyroid gland to function properly. In many countries, potassium iodide, KI, is added to table salt as a source of iodide ions.

(a) In the production of iodine, the final stage involves the reaction between sodium iodate(V) and sodium iodide in acidic solution.

The ionic half-equations for the redox processes are as follows.

$IO_3^- + 6H^+ + 5e^- \rightarrow \frac{1}{2}I_2 + 3H_2O$

$I^- \rightarrow \frac{1}{2}I_2 + e^-$

(i) Use these half-equations to deduce the full ionic equation for the production of iodine by this process. State symbols are not required.

(2)

(ii) Identify, by its **formula**, the oxidizing agent in the reaction in (a)(i). Justify your answer in terms of electron transfer.

(1)

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(b) On addition of concentrated sulfuric acid to crystals of potassium iodide, solid sulfur and a black solid are observed amongst the products formed.

(i) Identify, by name or formula, the black solid.

(1)

.....

(ii) Construct the ionic half-equation for the formation of sulfur from concentrated sulfuric acid.

State symbols are not required.

(2)

(iii) When iodide ions react with concentrated sulfuric acid, another product, **X**, can also be detected. **X** is a toxic gas with a smell of rotten eggs.

Identify **X**, by name or formula, and give the oxidation numbers of sulfur when **X** is formed from concentrated sulfuric acid.

(3)

Identity of gas **X**:

Oxidation number of S in sulfuric acid is .....

Oxidation number of S in **X** is .....

(c) The Recommended Dietary Allowance, RDA, of iodide ions in a balanced diet is 140 μg per day.

($1\ \mu g = 1 \times 10^{-6}$ g).

(i) Calculate the mass, in μg, of potassium iodide, KI, needed to supply the RDA of iodide ions.

Give your answer to **three** significant figures.

(2)

Mass of KI = ... μg

(ii) Suggest a reason, other than cost, why some countries do **not** add potassium iodide to table salt.

(1)

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(d) (i) When chlorine is passed over iodine crystals, iodine monochloride, ICl, is formed.

Iodine monochloride, ICl, is a liquid at room temperature whereas chlorine, Cl_2, is a gas.

Explain, in terms of intermolecular forces, why this is so.

(4)

(ii) When excess chlorine is passed over iodine monochloride, iodine trichloride, ICl_3, is formed. Draw the dot and cross diagram of ICl_3, showing only the outer electrons.

(2)

(e) When chlorine gas is bubbled into aqueous potassium iodide solution, a redox reaction occurs.

(i) Give the **ionic** equation for this reaction. State symbols are **not** required.

(1)

(ii) In a further experiment, 0.50 mol of chlorine gas was bubbled into an aqueous solution containing a mixture of 0.66 mol of sodium iodide and 0.66 mol of sodium bromide.

Assuming that **all the chlorine gas reacted**, calculate the number of moles of iodine and bromine produced. Justify your answer in terms of the relative reducing power of bromide and iodide ions.

(3)

The number of moles of iodine produced:

The number of moles of bromine produced:

Justification

.....

.....

.....

.....

(Total for Question 24 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS

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 damstadtium 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