Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Chemistry

Advanced Subsidiary

Paper 2: Core Organic and Physical Chemistry

Friday 25 May 2018 – Morning
Time: 1 hour 30 minutes

Paper Reference **8CH0/02**

Candidates must have: Data Booklet
Scientific calculator

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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5/4/5/2/1/1/1/1/

P 5 1 4 6 0 R A 0 1 2 4

Answer ALL questions.

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

☐ **A** HBr

☐ **B** H_2O

☐ **C** NH_3

☐ **D** CN^-

(Total for Question 1 = 1 mark)

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2 This question is about the molar volume of gases.

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

[The ideal gas equation is $pV = nRT$. Gas constant (R) = 8.31 J K^{-1} mol^{-1}]

(3)

(ii) At room temperature and pressure (r.t.p) another gas **B**, with formula XH_3, has a density of 1.42 g dm^{-3}.

Calculate the molar mass of the gas XH_3 and deduce the identity of the element X.

[The molar volume of gas **B** = 24 000 cm^3 mol^{-1} at r.t.p.]

(2)

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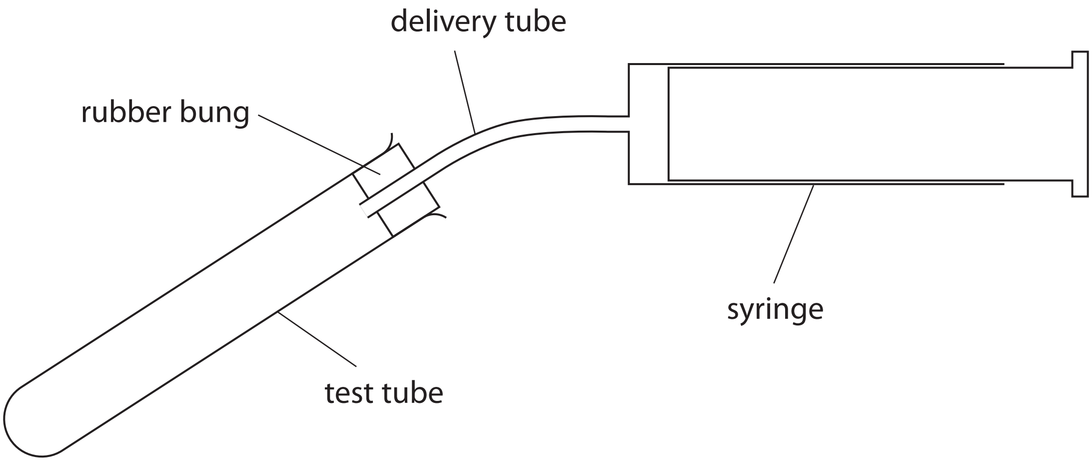
(b) The apparatus shown was used to measure the volume of gas evolved when a weighed mass of sodium carbonate reacted with dilute hydrochloric acid.



The following procedure was used.

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

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

Step **3** The container was then reweighed.

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

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

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

Results

Mass of container and sodium carbonate before transfer	=	20.135 g
Mass of container after transfer of the sodium carbonate	=	19.893 g
Mass of sodium carbonate used	=	0.242 g

The equation for the reaction is

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

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

Use your answers to decide which reactant is in excess.
Calculate the maximum volume of carbon dioxide which could be produced.

[Molar mass of Na_2CO_3 = 106.0 g mol^{-1}
Molar volume of gas = 24 000 cm^3 mol^{-1} at r.t.p.]

(5)

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

(2)

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(Total for Question 2 = 12 marks)

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3 This question is about the oxidation of ammonia.

One equation for the oxidation of ammonia is

$$4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g)$$

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

Expression

Units ....

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

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \qquad \Delta_r H = -904.8\,\text{kJ mol}^{-1}$$

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

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

$\Delta_f H$ (H_2O(g)) = −241.8 kJ mol^{-1}

(3)

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

(2)

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

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

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

(2)

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

(2)

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

(2)

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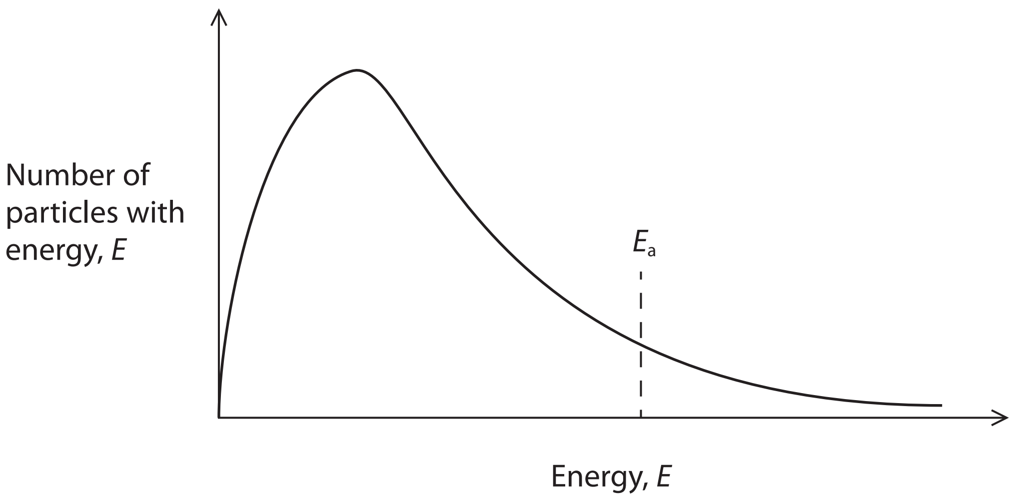
(d) The diagram shows a Maxwell-Boltzmann distribution of particle energies, including the activation energy, E_a, for a reaction.

(1)



An increase in temperature will

☒ **A** increase the area under the curve.

☒ **B** move the peak of the curve to the right.

☒ **C** raise the height of the peak.

☒ **D** move the position of the activation energy, E_a, to the left.

(Total for Question 3 = 14 marks)

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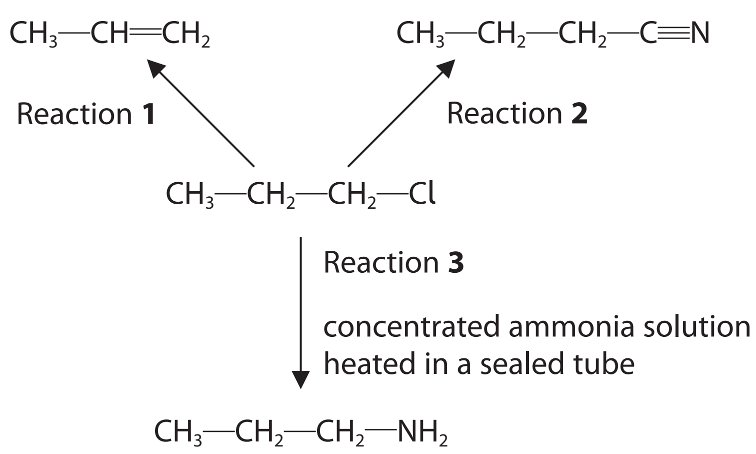
4 This question concerns halogenoalkanes.

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



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

(2)

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....

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

(2)

Reagent ....

Reason ....

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

(2)

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

(1)

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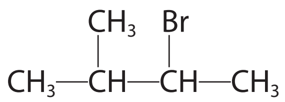
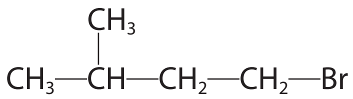
(b) The bromoalkanes, X, Y and Z, were each added to a mixture of aqueous silver nitrate and ethanol at 50 °C. The rate of hydrolysis was compared by measuring the time for a precipitate to appear.

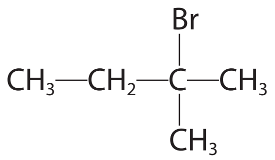
X



Y



Z



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

(1)

☒ **A** X, Y, Z

☒ **B** Z, X, Y

☒ **C** Z, Y, X

☒ **D** X, Z, Y

(Total for Question 4 = 8 marks)

5 This question concerns alkenes and some halogen compounds.

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

(i) This reaction is best described as

(1)

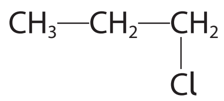
☒ **A** electrophilic substitution

☒ **B** electrophilic addition

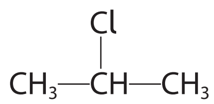
☒ **C** nucleophilic substitution

☒ **D** nucleophilic addition

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



1-chloropropane



2-chloropropane

1-chloropropane and 2-chloropropane are

(1)

☒ **A** *cis-trans* isomers

☒ **B** *E*/*Z* isomers

☒ **C** structural isomers

☒ **D** stereoisomers

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

(4)

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

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

(1)

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

(2)

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

(1)

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

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

$$Cl_2 + CH_2{=}CH_2 \rightleftharpoons CH_2Cl{-}CH_2Cl \qquad \Delta H = -178\,kJ\,mol^{-1}$$

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

(2)

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

$$CH_2Cl{-}CH_2Cl \rightarrow CH_2{=}CHCl + HCl \qquad \Delta H = +71\,kJ\,mol^{-1}$$

Both products are required for use in other processes.
Which method would be most suitable for the separation of these two products?

(1)

☒ **A** fractional distillation

☒ **B** solvent extraction using a separating funnel

☒ **C** heating under reflux

☒ **D** bubble through dilute alkali

(Total for Question 5 = 13 marks)

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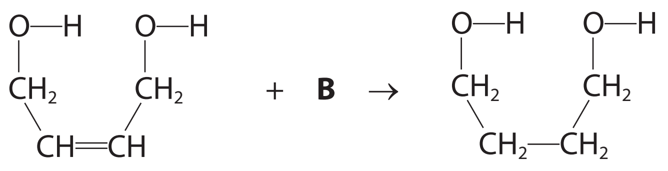
6 This question is about the synthesis and reactions of butane-1,4-diol.

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



but-2-ene-1,4-diol butane-1,4-diol

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

(2)

....

....

(ii) This reaction is best described as

(1)

☒ **A** hydrolysis

☒ **B** oxidation

☒ **C** reduction

☒ **D** substitution

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

(1)

....

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

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

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

(6)

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(Total for Question 6 = 10 marks)

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

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

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

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

(i) In the appropriate row, tick (✓) those titre values that should be used to find the mean, and use these titres to calculate it.
Write the value of the mean titre in the box provided in the table of results.

(2)

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

(2)

Name of indicator ....

Colour change at the end-point from .... to ....

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

$$C_2H_2O_4 + 2NaOH \rightarrow C_2O_4Na_2 + 2H_2O$$

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

(4)

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

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

(2)

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

(1)

☒ **A** halve the acid concentration and halve the acid volume

☒ **B** double the acid concentration and leave the acid volume unchanged

☒ **C** double the acid concentration and halve the acid volume

☒ **D** halve the acid concentration and leave the acid volume unchanged

(Total for Question 7 = 11 marks)

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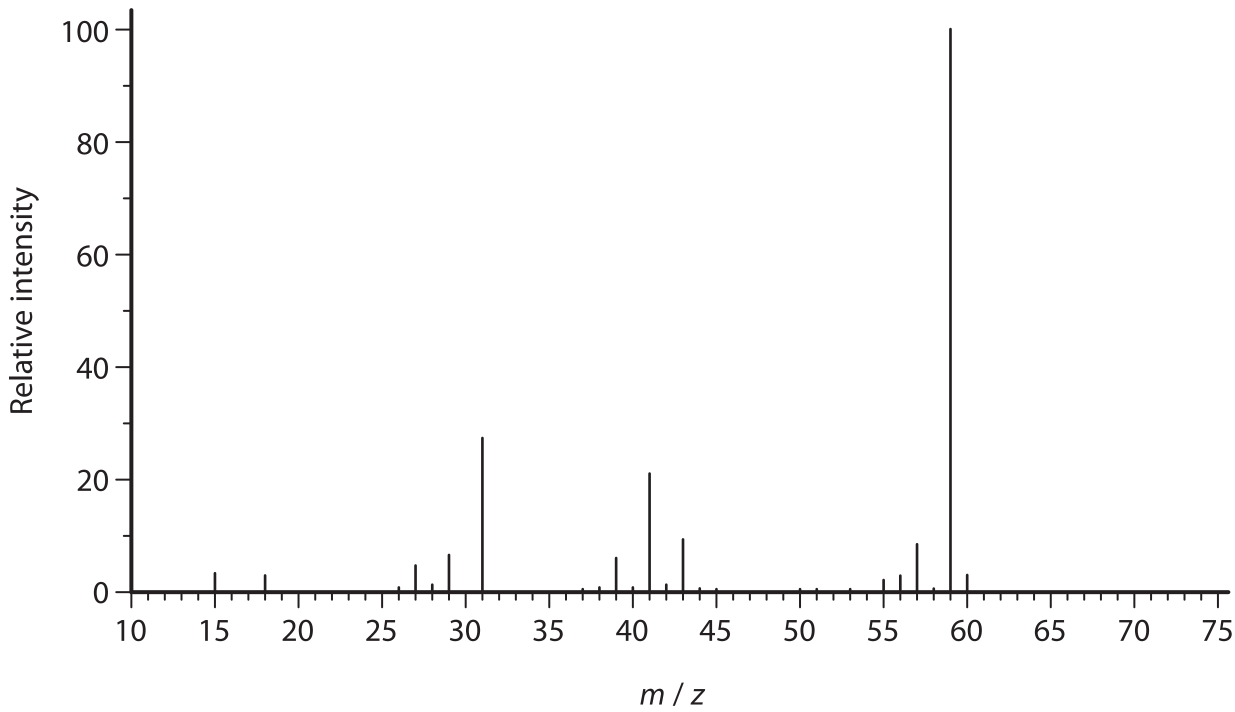
8 This question is about 2-methylpropan-2-ol.

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

(1)

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



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

(1)

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

(1)

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

$$C_4H_{10}O(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

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

(4)

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

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

(2)

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

(1)

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

(1)

☒ **A** orange to green

☒ **B** green to orange

☒ **C** purple to colourless

☒ **D** no change

(Total for Question 8 = 11 marks)

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1.0 **H** hydrogen 1

1	2											3	4	5	6	7	0 (8)
																	(18)
																	4.0 **He** helium 2
(1)	*(2)*											*(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

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