Write your name here

| Surname | Other names |
|---|---|
| | |

Centre Number | Candidate Number

# Edexcel GCE

# Chemistry

## Advanced Subsidiary
## Unit 2: Application of Core Principles of Chemistry

Tuesday 4 June 2013 – Afternoon
**Time: 1 hour 30 minutes**

Paper Reference
**6CH02/01R**

**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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7/6/7/1/1/

P 4 2 9 8 3 A 0 1 2 0

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 the following could be used to oxidize ethanol to ethanoic acid?

☒ **A** Concentrated $H_2SO_4$

☒ **B** $H^+/Cr_2O_7^{2-}$

☒ **C** $H^+/Cr^{3+}$

☒ **D** Concentrated NaOH solution

**(Total for Question 1 = 1 mark)**

**2** The term "reflux" is best described as

☒ **A** continuous evaporation and condensation.

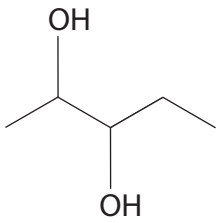
☒ **B** heating to evaporation and separation.

☒ **C** heating under reduced pressure and separation.

☒ **D** constant boiling.

**(Total for Question 2 = 1 mark)**

**3** The alcohol shown below can be classified as




☒ **A** just primary.

☒ **B** primary and secondary.

☒ **C** just secondary.

☒ **D** secondary and tertiary.

**(Total for Question 3 = 1 mark)**

**4**

$$C_2H_5Br + NaOH \rightarrow C_2H_4 + NaBr + H_2O$$

This reaction is an example of

☒ **A** addition.

☒ **B** elimination.

☒ **C** hydrolysis.

☒ **D** oxidation.

**(Total for Question 4 = 1 mark)**

**5** Which of the following is **not** a greenhouse gas?

☒ **A** $H_2O$

☒ **B** NO

☒ **C** $CH_4$

☒ **D** $O_2$

**(Total for Question 5 = 1 mark)**

**6** Which type of radiation is absorbed by molecules and results in the greenhouse effect?

☒ **A** Infrared

☒ **B** Microwave

☒ **C** Ultraviolet

☒ **D** X-ray

**(Total for Question 6 = 1 mark)**

**7** It is important to lower the level of carbon dioxide in the atmosphere because of concerns over which environmental problem?

☒ **A** Acid rain

☒ **B** Global warming

☒ **C** Non-biodegradability

☒ **D** Ozone depletion

**(Total for Question 7 = 1 mark)**

**8** The meaning of homolytic fission is

- ☒ **A** bond-breaking to form two free radicals.
- ☒ **B** bond-making to form two free radicals.
- ☒ **C** bond-breaking to form a cation and an anion.
- ☒ **D** bond-making to form a cation and an anion.

**(Total for Question 8 = 1 mark)**

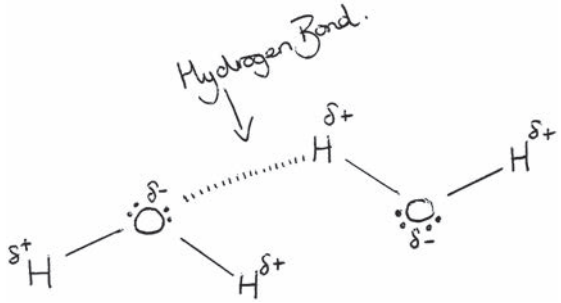
**9** What are the strongest forces between molecules of hydrogen fluoride, HF?

- ☒ **A** Dipole-dipole forces.
- ☒ **B** Hydrogen bonds.
- ☒ **C** Ionic interactions.
- ☒ **D** London forces.

**(Total for Question 9 = 1 mark)**

**10** The diagram below is taken from a student's examination paper. It shows the hydrogen bonding between two water molecules.

Identify the error in the diagram.




- ☒ **A** The H—O—H bond angle within each water molecule should be 90°.
- ☒ **B** There should only be one lone pair of electrons on each oxygen atom.
- ☒ **C** The O—H—O bond angle between the water molecules should be 180°.
- ☒ **D** The hydrogen atoms should be $\partial^-$ and the oxygen atoms should be $\partial^+$.

**(Total for Question 10 = 1 mark)**

**11** The boiling temperatures from methane to propane increase because

- ☒ **A** the number of ions increases, so there are stronger electrostatic attractions.
- ☒ **B** the covalent bonds are getting stronger, so require more energy to break.
- ☒ **C** there are more covalent bonds, so more energy is needed to break them.
- ☒ **D** the number of electrons increases, so there are stronger London forces.

**(Total for Question 11 = 1 mark)**

**12** In a chemical reaction, which of the following factors increases the proportion of particles that have sufficient energy to react?

- ☒ **A** A decrease in concentration
- ☒ **B** An increase in concentration
- ☒ **C** A decrease in temperature
- ☒ **D** An increase in temperature

**(Total for Question 12 = 1 mark)**

**13** A 'greener' chemical process will be one that

- ☒ **A** uses energy less efficiently.
- ☒ **B** forms a non-polluting waste product.
- ☒ **C** produces significant amounts of waste.
- ☒ **D** makes use of non-renewable resources.

**(Total for Question 13 = 1 mark)**

**14** Which of the following **cannot** alter the position of a chemical equilibrium?

- ☒ **A** Increasing the amount of catalyst
- ☒ **B** Increasing the reactant concentration
- ☒ **C** Increasing the temperature
- ☒ **D** Increasing the total pressure

**(Total for Question 14 = 1 mark)**

**15** $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91 \text{ kJ mol}^{-1}$

The conditions which would produce the greatest yield of methanol are

☒ **A** high pressure and high temperature.

☒ **B** high pressure and low temperature.

☒ **C** low pressure and low temperature.

☒ **D** low pressure and high temperature.

**(Total for Question 15 = 1 mark)**

**16** What is the oxidation number of chlorine in $Cl_2O_7$?

☒ **A** –1

☒ **B** +1

☒ **C** –7

☒ **D** +7

**(Total for Question 16 = 1 mark)**

**17** The concentration of a solution of potassium iodate(V) can be determined by the liberation of iodine, followed by titration with sodium thiosulfate.

A suitable indicator is

☒ **A** methyl orange.

☒ **B** phenolphthalein.

☒ **C** starch.

☒ **D** universal indicator.

**(Total for Question 17 = 1 mark)**

**18** The thermite reaction, shown below, is a useful industrial process.

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s)$$

The iron in this reaction undergoes

☒ **A** disproportionation.

☒ **B** oxidation.

☒ **C** redox.

☒ **D** reduction.

**(Total for Question 18 = 1 mark)**

**19** Which of the following molecules has a linear shape and bond angles of 180°?

☒ **A** $CH_4$

☒ **B** $H_2O$

☒ **C** $CO_2$

☒ **D** $SF_6$

**(Total for Question 19 = 1 mark)**

**20** What would be the experimental observations if chlorine gas was bubbled through potassium iodide solution, followed by the addition of cyclohexane?

☒ **A** The solution turns brown, then two layers are produced and the top layer is purple.

☒ **B** A white precipitate is formed, which then dissolves to leave a colourless solution.

☒ **C** Bubbles of gas are seen and then a brown precipitate is formed.

☒ **D** The solution remains colourless, and then two layers are seen with the bottom layer being brown.

**(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** This is a question about Group 2 compounds.

Limewater is a solution of calcium hydroxide, commonly used in the identification of carbon dioxide gas. Since calcium hydroxide is only sparingly soluble in water, technicians often make the solution by adding an excess of the solid calcium hydroxide to the required volume of deionised water, shaking the container and then leaving the mixture to settle. In this way, a saturated solution is produced but it can be of variable concentration.

Two students were each given a sample of limewater, from the same batch, in order to determine its concentration. Using 50.0 $cm^3$ portions of the limewater, they carried out titrations using 0.100 mol $dm^{-3}$ hydrochloric acid. One of the students obtained the following results:

| Titration | Trial | 1 | 2 |
|---|---|---|---|
| Final Volume /$cm^3$ | 14.50 | 28.60 | 42.70 |
| Initial Volume /$cm^3$ | 0.00 | 14.50 | 28.60 |
| Volume Added /$cm^3$ | 14.50 | 14.10 | 14.10 |

The student decided that the mean titre was 14.10 $cm^3$

The equation for the reaction is:

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

(a) (i) Calculate the number of moles of hydrochloric acid that reacted.

**(1)**

(ii) Calculate the number of moles of calcium hydroxide, $Ca(OH)_2$, that reacted with the acid.

**(1)**

(iii) Calculate the concentration of $Ca(OH)_2$, in mol $dm^{-3}$, in this sample of limewater.

**(1)**

(iv) Calculate the concentration of $Ca(OH)_2$, in g $dm^{-3}$, in this sample of limewater. Use the Periodic Table as a source of data.

**(2)**

(v) This student did not include the trial value when calculating the mean titre. Explain why.

**(1)**

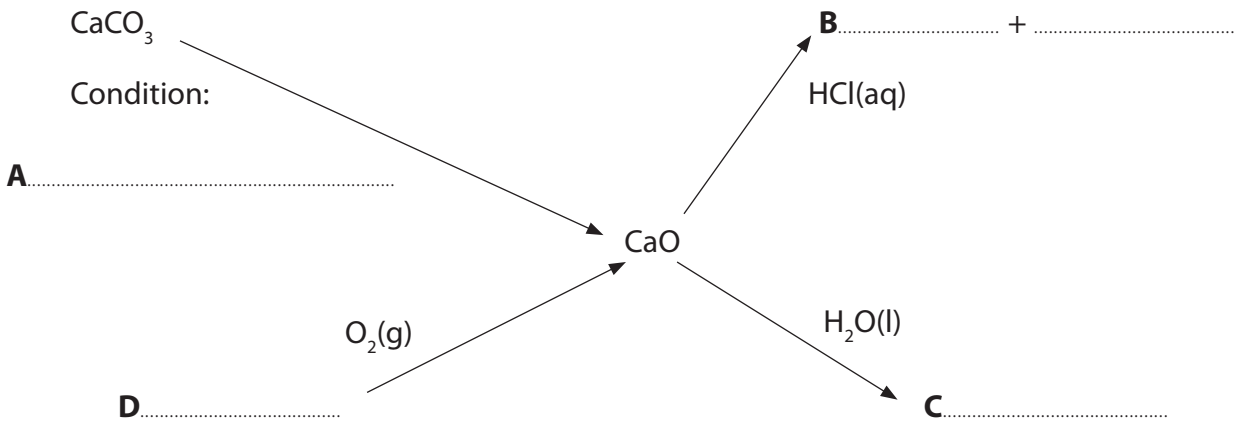
(vi) The second student obtained a different mean titre value for the experiment and thought that this difference may be due to the use of a faulty pipette.

Suggest a simple method, involving distilled water and a balance, by which the accuracy of the pipette in measuring out exactly 50.0 $cm^3$ could be checked.

**(2)**

(b) Complete the missing details from the reaction flowchart shown below, giving the condition for **A** and using chemical formulae for answers **B**, **C** and **D**. State symbols are not required.

**(4)**




(c) In certain areas of the UK, calcium and magnesium carbonates tend to be deposited as an off-white solid on the inside surface of pipes and the surface of heating elements in kettles. These deposits can be removed by treatment with a weak acid. An equation for this is shown below.

$$CaCO_3(s) + 2HA(aq) \rightarrow CaA_2(aq) + H_2O(l) + CO_2(g)$$

State **one** observation, other than the solid disappearing, that would be made when the above reaction is carried out.

**(1)**

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(d) The thermal stability of these carbonates depends on a combination of factors, including the size of their lattice energies.

Explain why the lattice energy of calcium carbonate is less exothermic than that of magnesium carbonate.

**(2)**

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(e) Calcium and magnesium ions can be distinguished by the use of a flame test. State the difference in the flame colour and explain how colours in a flame are produced in terms of electronic transitions.

**(3)**

Calcium.....

Magnesium.....

Colour produced by.....

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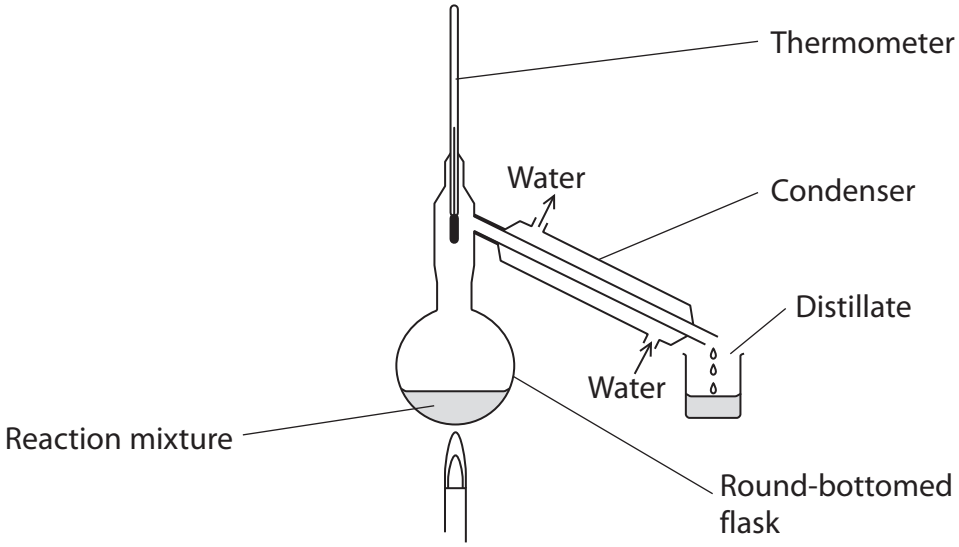
**(Total for Question 21 = 18 marks)**

**22** Ethane-1,2-diol, $CH_2OHCH_2OH$, is commonly used in antifreeze for cars to lower the freezing temperature of the water in the car radiator. It reacts in a similar way to ethanol but both of the alcohol groups can react.

(a) Write an equation for the **complete** reaction between sodium and ethane-1,2-diol. State symbols are **not** required.

**(2)**

(b) Ethane-1,2-diol is very quickly oxidized to ethanedioic acid, $(COOH)_2$, even under the conditions shown below.




However, ethanol requires stronger oxidizing conditions to be converted into ethanoic acid.

Explain how you would change the above apparatus to achieve this oxidation of ethanol.

**(2)**

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(c) Draw the **skeletal** formula of ethanedioic acid.

**(1)**

(d) Explain why phosphorus(V) chloride, $PCl_5$, would not be a suitable reagent to be used to distinguish between ethane-1,2-diol and ethanedioic acid.

**(1)**

(e) (i) Depending on the reaction conditions, ethanol can be oxidized to either an aldehyde or to carboxylic acid. Infrared spectroscopy is a suitable technique for determining whether the oxidation product obtained is an aldehyde or a carboxylic acid.

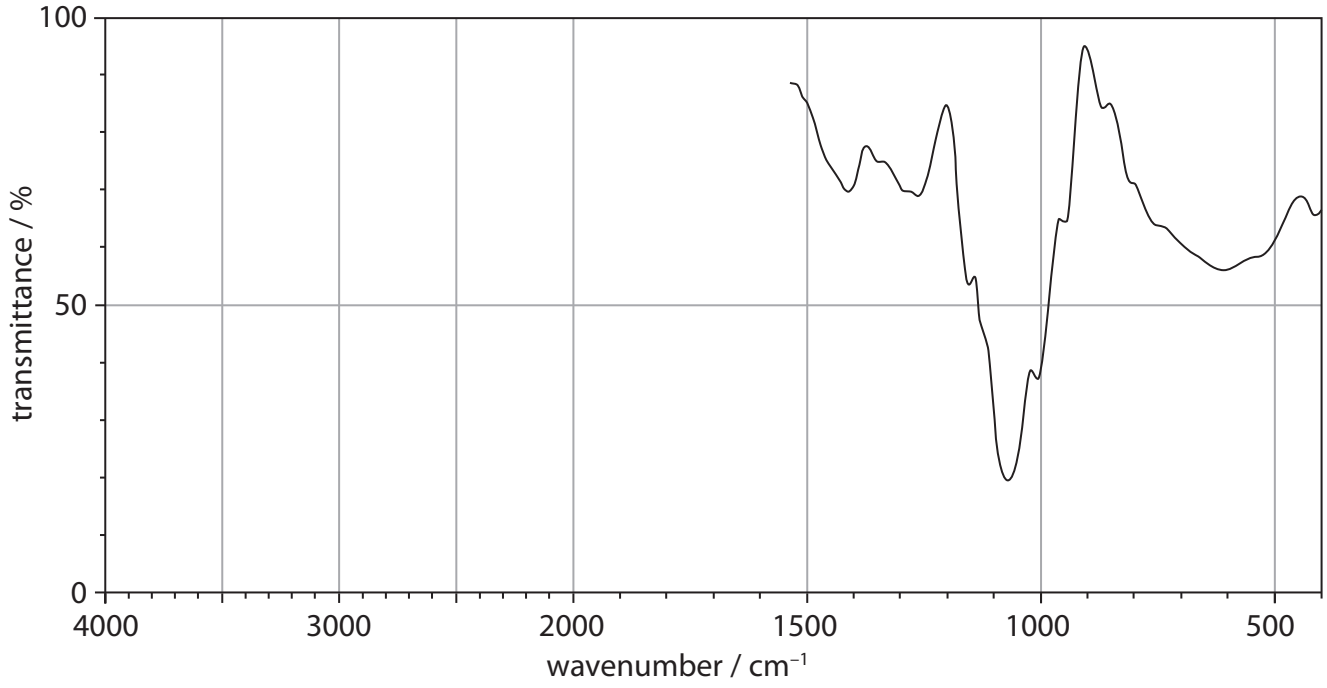
Draw, on the spectrum below, any peak(s) that you would expect to see between 4000 and 1500 $cm^{-1}$ if the product was an aldehyde and **not** a carboxylic acid.

**(2)**

**DATA**

The IR absorption ranges associated with some organic functional groups are given below:

| | |
|---|---|
| O—H stretching in alcohols (variable, broad) at | 3750 – 3200 $cm^{-1}$ |
| O—H stretching in carboxylic acids (weak) at | 3300 – 2500 $cm^{-1}$ |
| C═O stretching in aldehydes (strong) at | 1740 – 1720 $cm^{-1}$ |
| C═O stretching in ketones (strong) at | 1700 – 1680 $cm^{-1}$ |
| C═O stretching in carboxylic acids, alkyl (strong) at | 1725 – 1700 $cm^{-1}$ |
| C—H stretching in aldehydes (weak) at | 2900 – 2820 $cm^{-1}$ |
| and (weak) at | 2775 – 2700 $cm^{-1}$ |




(ii) The infrared spectrum of the distillate from the reaction in (e)(i) included a peak at 3750–3200 $cm^{-1}$.

What substance is likely to have caused this?

**(1)**

(iii) Mass spectrometry can be used to identify the products of the oxidation of ethanol. Suggest the formula of a fragment that would show when **ethanoic acid** is produced and would not be present in either ethanol or ethanal.

**(1)**

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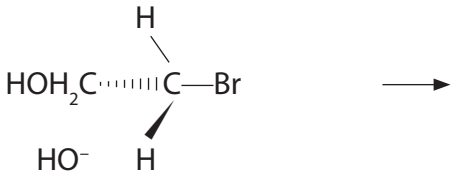
(f) Treatment of 2-bromoethanol, $CH_2BrCH_2OH$, with aqueous sodium hydroxide would be one way to produce ethane-1,2-diol.

(i) Complete a possible mechanism for this reaction in the space below.

**(3)**




(ii) Classify the mechanism and type of reaction in (f)(i):

**(2)**

Mechanism .....

Type .....

(g) Aqueous silver nitrate can be used to test for the presence of bromide ions. Write an ionic equation for the reaction. Include **state symbols** in your answer.

**(2)**

Ionic Equation

*(h) It can be difficult to distinguish between the colours of the silver halides. The use of solutions of ammonia can be very helpful.

A silver halide dissolved in concentrated ammonia to form a colourless solution.

Explain why this result does not prove conclusively that the silver halide was silver bromide and give a further test to confirm that the silver halide is silver bromide.

**(2)**

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**(Total for Question 22 = 19 marks)**

**TOTAL FOR SECTION B = 37 MARKS**

## SECTION C

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

**23** Nanorockets have generated a lot of excitement due to their potential uses in the medicinal field, such as in the delivery of drugs around the body.

Some bacteria have the ability to move at speeds of 100 times their body length per second. Scientists in one study made nanorockets that reached speeds of up to 200 times their length per second. These scientists made their rockets on a nano scale ($10^{-9}$) from nanotubes with platinum coated on the inside as a catalyst. The fuel used to power these tiny rockets was hydrogen peroxide, $H_2O_2$, which forms water and oxygen gas when undergoing decomposition.

Other forms of nanotechnology are already being used. For example, some sun creams use nanoparticles of titanium(IV) oxide which form an invisible protective layer against UV radiation.

(a) Write an equation for the catalytic decomposition of hydrogen peroxide. State symbols are **not** required.

**(1)**

(b) Draw a dot and cross diagram to show the electronic configuration of the oxygen gas produced in the breakdown of the hydrogen peroxide (only outer electrons should be shown).

**(1)**

(c) Suggest a dot and cross diagram for the hydrogen peroxide molecule in which each oxygen atom is covalently bonded to one hydrogen atom (only outer electrons should be shown).

**(2)**

*(d) The bond angles in hydrogen peroxide are similar to those in a water molecule. Suggest a bond angle for hydrogen peroxide and reasons for your value.

**(3)**

Bond Angle.....

Reasons.....

.....

.....

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(e) In the future, the aim is to develop a nanorocket that can use a fuel such as glucose rather than hydrogen peroxide. Suggest an advantage of using glucose and a disadvantage of using hydrogen peroxide.

**(2)**

Glucose advantage.....

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Hydrogen peroxide disadvantage.....

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(f) The boiling temperature of hydrogen peroxide is relatively high, about 150 °C, for such a small molecule. Explain fully why this is the case.

**(2)**

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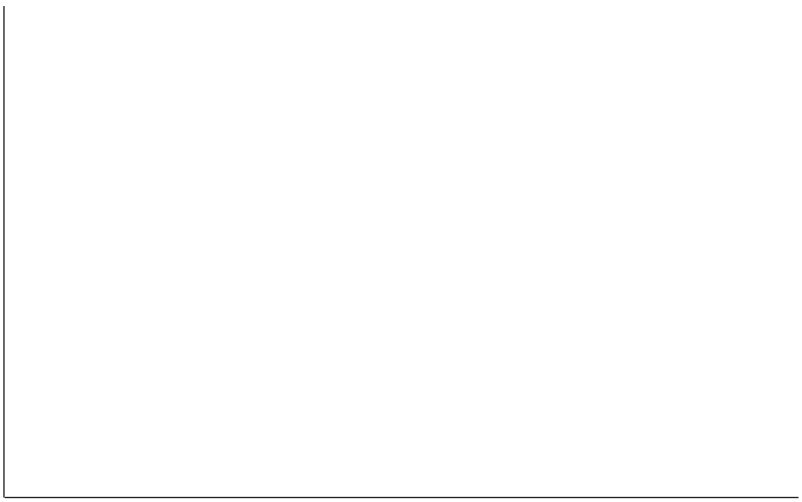
*(g) It is suggested that hydrogen peroxide is a polar liquid.

Describe how you might carry out an experiment to test whether a liquid is polar.

**(3)**

*(h) The speed of the nanorockets is controlled by the rate of decomposition of hydrogen peroxide. The speed at the body temperature of 37 °C is faster than under normal laboratory conditions. Draw Maxwell-Boltzmann distribution curves on the axes below. Label your diagram and use it to explain why the increase in the speed of the rockets occurred.

**(4)**



(i) The scientists used platinum in their nanorockets. Explain the catalytic role of the platinum in the reaction.

**(2)**

(j) Nanotubes can be made from carbon. These carbon nanotubes can be good electrical conductors in a similar way to graphite.

Explain why they are able to conduct electricity.

**(2)**

(k) Some scientists are concerned that the use of nanoparticles in cosmetic products, such as sun cream, could pose a health hazard. Suggest why this might be the case.

**(1)**

**(Total for Question 23 = 23 marks)**

**TOTAL FOR SECTION C = 23 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 | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | relative atomic mass<br>**atomic symbol**<br>name<br>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 |