Chemistry

UNIT: 4CH1
Science (Double Award) 4SD0
PAPER: 1CR

Monday 22 May 2023 – Morning

Time: 2 hours

Total Marks

In the boxes below, write your name, centre number and candidate number.

Surname	
Other names	
Centre Number	
Candidate Number	

Pearson

YOU MUST HAVE

Calculator, ruler

YOU WILL BE GIVEN

Diagram Booklet, Periodic Table

INSTRUCTIONS

If pencil is used for diagrams / sketches / graphs it must be dark (HB or B).

Answer ALL questions.

Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – there may be more space than you need.

Show all the steps in any calculations and state the units.

INFORMATION

The total mark for this paper is 110.

The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.

There may be spare copies of some diagrams.

ADVICE

Read each question carefully before you start to answer it.

Write your answers neatly and in good English.

Try to answer every question.

Check your answers if you have time at the end.

_____

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   This question is about oxygen.

   (a) Oxygen can be stored in tanks as a liquid or as a gas.

      (i)   Look at the diagram for Question 1(a)(i) in the Diagram Booklet. Complete the diagram to show the arrangement of six more particles in a gas.
             (1 mark)

      (ii)   Give a reason why a tank can store much more oxygen as a liquid.
             (1 mark)

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(continued on the next page)

Turn over

1(a) continued.

(iii) Identify a hazard when storing oxygen as a gas.
(1 mark)

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(b) Sulfur burns in oxygen to form sulfur dioxide.

(i) Give one observation that can be made when sulfur burns in oxygen.
(1 mark)

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(continued on the next page)

1(b) continued.

      (ii) **Some universal indicator is added to sulfur dioxide.**

           Explain the final colour of the universal indicator.
           (2 mark)

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(Total for Question 1 = 6 marks)

2 This question is about mixtures and compounds.

(a) The list gives some techniques used to separate mixtures.

crystallisation
filtration
fractional distillation
simple distillation

Look at the table for Question 2(a) in the Diagram Booklet. It lists some substances and mixtures.

Complete the table using words from the list to show the best technique to obtain the named substance from each mixture.
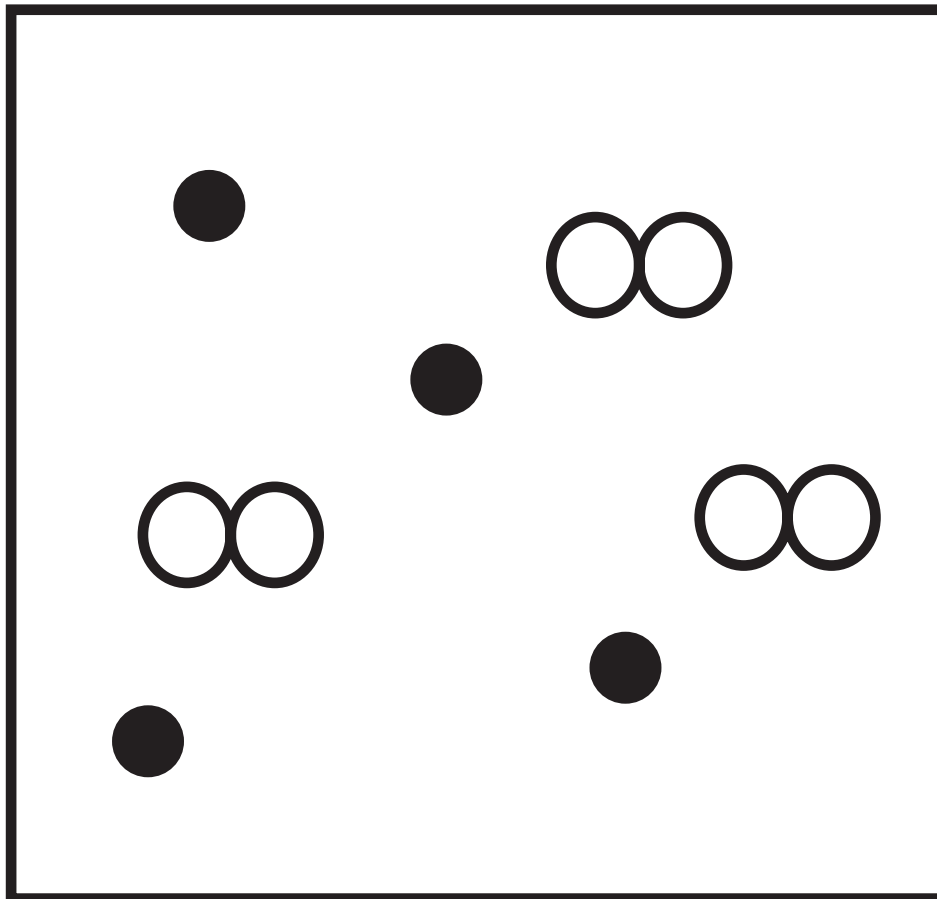
Each technique may be used once, more than once or not at all.
(3 marks)

(continued on the next page)

2 **continued.**

(b) State how the box represents a mixture.
   (1 mark)

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(continued on the next page)

Turn over

2 **continued.**

(c) Food colourings are mixtures of food dyes.

A student uses paper chromatography to separate the food dyes contained in food colouring D.

The student places spots of three food dyes A, B and C and food colouring D on chromatography paper.

Look at the diagram for Question 2(c) in the Diagram Booklet. It shows the appearance of the paper after the experiment.

Describe the composition of food colouring D. (2 marks)

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(continued on the next page)

2   continued.

(d) A compound has the formula $Ca(HCO_3)_2$

(i)   Determine the number of different elements in $Ca(HCO_3)_2$
(1 mark)

_____

_____

(ii) Determine the number of atoms in the formula of $Ca(HCO_3)_2$
(1 mark)

_____

_____

(Total for Question 2 = 8 marks)

3   (a) Look at the diagram for Question 3(a) in the Diagram Booklet. It represents an atom of an element.

(i)   What is the particle labelled W?
(1 mark)

☐ A   electron

☐ B   neutron

☐ C   nucleus

☐ D   proton

(ii) An atom of this element contains 13 neutrons.

What is the mass number of this element?
(1 mark)

☐ A   12

☐ B   13

☐ C   25

☐ D   49

Turn over

3(a)   continued.

(iii) State why atoms have no overall charge.
(1 mark)

_____

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(iv) What is the charge on the ion usually formed from this element?
(1 mark)

☐ **A   1+**

☐ **B   2+**

☐ **C   1–**

☐ **D   2–**

(continued on the next page)

3   continued.

(b) There are two isotopes of the element lithium.

$$^{6}_{3}Li \qquad ^{7}_{3}Li$$

(i)   State why both isotopes react in the same way.
(1 mark)

_____

_____

_____

(continued on the next page)

3(b) continued.

    (ii) A sample of lithium contains 7·60% $^6_3$Li and 92·4% $^7_3$Li

       Calculate the relative atomic mass, A_r, of this sample of lithium.

       Give your answer to two decimal places.
       (3 marks)

       A_r = _____

(Total for Question 3 = 8 marks)

Turn over

4 This question is about gases.

(a) Look at the table for Question 4(a) in the Diagram Booklet. It gives information about some gases.

Complete the table by choosing a gas from the list that matches the information.

carbon dioxide
carbon monoxide
helium
methane
nitrogen
oxygen

You may use each gas once, more than once, or not at all.
(4 marks)

(continued on the next page)

4   continued.

(b) Look at the diagram for Question 4(b) in the
     Diagram Booklet. A teacher uses this apparatus
     to determine the percentage of oxygen in a
     sample of air.

     This is the teacher's method.

     ● record the total volume of air in the apparatus

     ● heat the copper powder

     ● use the syringes to pass air over the heated
       copper powder several times

     ● allow the remaining gas to cool and record
       its volume

     The copper powder turns black.

     (i)   State why the copper powder turns black.
           (1 mark)

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(continued on the next page)

4(b) continued.

      (ii) **Give a reason why the remaining gas is allowed to cool before its volume is recorded. (1 mark)**

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4(b)   continued.

(iii) At the start of the experiment, the total volume of air in the apparatus is $138\,cm^3$.

At the end of the experiment, the volume of gas remaining is $108\,cm^3$.

Calculate the percentage of oxygen in the sample of air.

Assume that all the oxygen has reacted.
(2 marks)

percentage of oxygen = _____%

(Total for Question 4 = 8 marks)

5 This question is about iron.

(a) One problem with iron is that it rusts.

(i) Name the two substances that iron reacts with when it rusts.
(2 marks)

1 _____

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2 _____

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(ii) State what type of reaction occurs when iron rusts.
(1 mark)

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(continued on the next page)

5 **continued.**

(b) **Iron can be prevented from rusting by painting or by coating with zinc.**

   (i) **Explain how painting prevents iron from rusting.**
   (2 marks)

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   (ii) **Name the process used to coat iron with zinc.**
   (1 mark)

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(continued on the next page)

Turn over

5(b) **continued.**

      (iii) **Explain why a layer of zinc protects iron from rusting, even if the layer of zinc is scratched. (2 marks)**

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5 **continued.**

(c) Iron is formed when aluminium reacts with iron(III) oxide.

This is the equation for the reaction.

$$2Al + Fe_2O_3 \longrightarrow Al_2O_3 + 2Fe$$

(i) Explain what this reaction shows about the relative reactivities of aluminium and iron.
(2 marks)

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(continued on the next page)

5(c) continued.

      (ii) **Explain which substance acts as an oxidising agent in this reaction.**
          (2 marks)

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(Total for Question 5 = 12 marks)

6 Look at the diagram for Question 6 in the Diagram Booklet. A student uses this apparatus to investigate the rate of reaction when hydrogen peroxide solution decomposes.

This is the equation for the reaction.

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

(a) Give a reason why the gas that collects in the gas syringe is not pure oxygen.
(1 mark)

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(continued on the next page)

6   continued.

(b) The rate of reaction can be increased by adding a catalyst to the hydrogen peroxide solution.

Describe how a catalyst increases the rate of a reaction.
(2 marks)

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(continued on the next page)

Turn over

6 continued.

(c) These solids catalyse the decomposition of hydrogen peroxide solution.

- lead(IV) oxide

- manganese(IV) oxide

Describe a method that the student could use to find out which solid is the more effective catalyst. (5 marks)

Answer space continues on the next page.

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6(c)   continued.

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Turn over

6   continued.

**(d) A student investigates the decomposition
of a solution of hydrogen peroxide at
different temperatures.**

**Look at the graph for Question 6(d) in the Diagram
Booklet. It shows how the total volume of oxygen
collected in the syringe changes with time when
the solution is at a temperature of 20 °C.**

**On the grid, draw the curve the student would
obtain at a temperature of 40 °C when all other
conditions are kept the same.**
(2 marks)

(Total for Question 6 = 10 marks)

7   Look at the apparatus for Question 7 in the Diagram
    Booklet. A teacher uses this apparatus to test the
    products of the combustion of liquid hydrocarbons.

    (a) Explain the change in appearance that occurs in
         the limewater.
         (2 marks)

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    _____

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(continued on the next page)

7   continued.

(b) The equation represents the complete combustion
of an alkene.

C_nH_{2n} + oxygen $\longrightarrow$ carbon dioxide + nH_2O

Complete combustion of 0·0100 mol of the alkene
produces 2·16 g of water.

(i)   Determine the molecular formula of
this alkene.
(3 marks)

[for H_2O, M_r = 18]

molecular formula =

_____

(continued on the next page)

7(b)   continued.

(ii)   **Give a reason why the mass of pure water that collects in the U-tube is less than 2·16 g.**
(1 mark)

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(iii)   **Give a physical test to show that the water that collects in the U-tube is pure.**
(2 marks)

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(continued on the next page)

Turn over

7   continued.

(c) **The teacher burns 30·0 g of heptane.**

This is the equation for the complete combustion of heptane.

$$C_7H_{16} \ + \ 11O_2 \ \longrightarrow \ 7CO_2 \ + \ 8H_2O$$

Calculate the minimum mass of oxygen needed for the complete combustion of 30·0 g of heptane. (3 marks)

[for C_7H_{16}, M_r = 100   for O_2, M_r = 32]

minimum mass of oxygen = _____ g

(Total for Question 7 = 11 marks)

8 Diamond, graphite and C_{60} fullerene are all forms of the element carbon.

Look at the diagram for Question 8 in the Diagram Booklet. It shows the structures of these three substances.

(a) Explain why graphite conducts electricity.
(2 marks)

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(continued on the next page)

8   **continued.**

**(b) Explain why diamond is hard but graphite is soft.
      (2 marks)**

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(continued on the next page)

8 **continued.**

(c) Doctors use C_{60} fullerene to deliver medicines to certain parts of the body, so that the medicine does not damage other parts of the body.

Suggest why C_{60} fullerene is suitable for this purpose.
(1 mark)

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(Total for Question 8 = 5 marks)

Turn over

9   This question is about ionic compounds.

(a) Calcium nitrate has the formula $Ca(NO_3)_2$

(i)   Give the formula of each ion in calcium nitrate.
(2 marks)

calcium ion

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_____

nitrate ion

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(continued on the next page)

9(a)   continued.

   (ii) Explain why calcium nitrate has a high melting point.

   Refer to structure and bonding in your answer. (4 marks)

Answer space continues on the next page.

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Turn over

9(a)(ii)   continued.

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(iii) Calcium nitrate decomposes when heated.

Complete the chemical equation for the decomposition of calcium nitrate.
(1 mark)

_____$Ca(NO_3)_2 \longrightarrow$ _____CaO + _____NO_2 + _____O_2

(continued on the next page)

9 **continued.**

(b) A student has four unlabelled beakers, each containing a colourless solution of a different salt.

These are the four salt solutions.

- calcium bromide
- calcium chloride
- sodium chloride
- sodium sulfate

Describe a series of tests to identify each solution.

Do not refer to safety precautions in your answer. (6 marks)

Answer space continues on the next 2 pages.

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9(b) **continued.**

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9(b) **continued.**

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(Total for Question 9 = 13 marks)

10 This question is about propene.

   (a) (i) The structural formula of propene
             is $CH_3CH{=}CH_2$

             Look at the diagram for Question 10(a)(i) in the
             Diagram Booklet. Complete the dot-and-cross
             diagram for a molecule of propene.
             (2 marks)

        (ii) Describe the forces of attraction that hold the
             atoms together in a molecule of propene.
             (2 marks)

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(continued on the next page)

Turn over

10   continued.

(b) The alkane pentadecane has the formula $C_{15}H_{32}$

Describe how propene can be produced
from pentadecane.
(2 marks)

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(continued on the next page)

10 continued.

(c) Propene is used to make poly(propene).

(i) Look at the equation for Question 10(c)(i) in the Diagram Booklet. Complete the equation for the formation of poly(propene).
(2 marks)

(ii) Explain why the disposal of poly(propene) in landfill sites is a problem.
(2 marks)

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(continued on the next page)

10 continued.

(d) Propene can be converted into compound **X**.

(i) Compound **X** contains these percentages by mass.
- carbon 60%
- hydrogen 13·3%
- oxygen 26·7%

Compound **X** has an M_r of 60

Determine the molecular formula of compound **X**.
(3 marks)

molecular formula =

_____

Turn over

10(d) continued.

      (ii) Propene and compound X both have simple molecular structures.

          Explain why compound X has a higher boiling point than propene.
          (2 marks)

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(Total for Question 10 = 15 marks)

11 A student uses this method to investigate the temperature change when solid sodium hydrogencarbonate is added to ethanoic acid solution.

- pour $100 \, cm^3$ of ethanoic acid solution into a polystyrene cup

- record the temperature of the ethanoic acid solution

- add a 1 g portion of sodium hydrogencarbonate to the ethanoic acid solution and stir

- record the new temperature

- add further 1 g portions of sodium hydrogencarbonate, stirring and recording the temperature after each portion is added

(continued on the next page)

11   continued.

The table shows the student's results.

Mass of sodium hydrogencarbonate added in g	Temperature in °C
0	20·8
1	19·4
2	18·1
3	18·0
4	16·4
5	15·8
6	15·3
7	15·3
8	15·3

(a) (i)   Look at the grid for Question 11(a) in the
            Diagram Booklet. Plot the student's results on
            the grid.
            (1 mark)

     (ii) Draw a circle around the anomalous result.
            (1 mark)

     (iii) Draw a curve of best fit.
            (1 mark)

11 continued.

(b) (i) Explain why using a polystyrene cup makes the results more accurate.
(2 marks)

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(ii) Suggest a mistake the student might have made to cause the anomalous result.
(1 mark)

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Turn over

11(b)   continued.

      **(iii) State how the results show the reaction
           is complete.
           (1 mark)**

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      **(iv) State how the results show that the reaction
           is endothermic.
           (1 mark)**

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11   continued.

(c) Use the results to calculate the heat energy
change, Q, in joules.
(2 marks)

[for $1 \cdot 0 \, cm^3$ of ethanoic acid solution, mass = $1 \cdot 0 \, g$]

[for ethanoic acid solution, c = $4 \cdot 2 \, J/g/°C$]

Q = _____ J

(continued on the next page)

11   continued.

(d) **The student repeats the experiment starting with a different volume of ethanoic acid solution.**

The student uses 7·0 g of sodium hydrogencarbonate to neutralise the ethanoic acid solution.

The heat energy change, Q, is 3200 J.

Calculate the molar enthalpy change, ΔH, in kJ / mol.

Include a sign with your answer.
(4 marks)

[for sodium hydrogencarbonate, M_r = 84]

Answer space continues on the next page.

11(d) **continued.**

$\Delta H =$ _____ **kJ/mol**

(Total for Question 11 = 14 marks)

TOTAL FOR PAPER = 110 MARKS
END OF PAPER