Write-on

Chemistry A
Unit H432

Practice Paper 1D

Name	

Time allowed
2 hours 15 minutes

Information
- The total marks available for this paper is 100. The number of marks available for each question is shown in brackets.
- Answer all questions and show all working

You will need:
An OCR A Chemistry data sheet

You may use:
- A scientific or graphical calculator
- A pencil for graphs and drawings
- A ruler

Question	Mark
MCQs	
16	
17	
18	
19	
20	
21	
Total	

Paper 1D

SECTION A

You should aim to finish this section within 20 minutes.

1 A compound contains (by mass) 19.3 % sodium, 27.0 % sulfur and 53.7 % oxygen.

Identify which of the following is a possible identity for the compound.

A $NaSO_3$

B NaS_2O_3

C $Na_2S_2O_7$

D $Na_2S_2O_8$

Your answer ☐

2 The first five ionisation energies for an element are given. Identify the group it is found in.

590 kJ mol^{-1} 1145 kJ mol^{-1} 4912 kJ mol^{-1} 6491 kJ mol^{-1} 8153 kJ mol^{-1}

A 2

B 3

C 4

D 5

Your answer ☐

3 Identify the change in coordination of copper on addition of hydrochloric acid to a solution of aqueous copper ions.

A Increases by 2

B Stays the same

C Decreases by 2

D Decreases by 3

Your answer ☐

4 Give the unit of the rate constant for a reaction that is second order with respect to two different reactants.

A $mol^3\ dm^{-9}\ s^{-1}$

B $mol^{-3}\ dm^{-9}\ s^{-1}$

C $mol^3\ dm^9\ s^{-1}$

D $mol^{-3}\ dm^9\ s^{-1}$

Your answer ☐

5 A container of variable volume contains water and carbon monoxide at room temperature. The contents are heated over a catalyst, forming carbon dioxide and hydrogen. The contents are allowed to return to room temperature and pressure.

What is the change in volume of gas between the container at room temperature before and after the reaction?

A Increase of 24.0 dm^3

B Increase of 48.0 dm^3

C Decrease of 48.0 dm^3

D No change in volume

Your answer ☐

6 Predict the geometry around S in the molecule H_2SO_3, which contains two O–H bonds.

A Trigonal planar

B Pyramidal

C Tetrahedral

D Trigonal bipyramidal

Your answer ☐

7 An electrochemical cell gave an initial reading of +1.23 V on a voltmeter. After half an hour this had decreased by 25 %. Suggest why.

A The conditions were not standard to begin with

B After half an hour it had reached equilibrium

C A proportion of the reactants had been used up

D The reaction had finished

Your answer ☐

8 A first-order reaction took 48 seconds for the concentration of the reactant to decrease by a half. What is the value of the rate constant?

A 0.021

B 96

C 0.014

D 69

Your answer ☐

9 A scientist performed a titration to determine that the equilibrium constant for a reaction was 3.95×10^{-5}. Another scientist used a data logger to monitor reactant concentration, and obtained the same value for the equilibrium constant.

What does this show?

A The first scientist's experiment is accurate.

B The first scientist's experiment is precise.

C The first scientist's experiment is reproducible.

D The first scientist's experiment has a low uncertainty.

Your answer ☐

10 Give the pH of a 0.0500 mol dm^{-3} solution of NaOH at 298 K. $K_w = 1.00 \times 10^{-14}$.

A 12.7

B 15.3

C 29.2

D 11.4

Your answer ☐

11 Which of the following gives the correct expression for the lattice enthalpy of calcium chloride?

A $\Delta H_{hyd}(Ca^{2+}) + 2\Delta H_{hyd}(Cl^-) + \Delta H_{sol}(CaCl_2)$

B $\Delta H_{hyd}(Ca^{2+}) + 2\Delta H_{hyd}(Cl^-) - \Delta H_{sol}(CaCl_2)$

C $-\Delta H_{hyd}(Ca^{2+}) - 2\Delta H_{hyd}(Cl^-) + \Delta H_{sol}(CaCl_2)$

D $-\Delta H_{hyd}(Ca^{2+}) - 2\Delta H_{hyd}(Cl^-) - \Delta H_{sol}(CaCl_2)$

Your answer ☐

12 Which of these statements is not true?

A For a positive emf, at least one of the half cells must have a greater reduction potential than the standard hydrogen electrode.

B The standard hydrogen electrode can include 0.500 mol dm^{-3} sulfuric acid.

C To find the standard reduction potential of the Fe^{3+}/Fe^{2+} half cell, 0.500 mol dm^{-3} solutions of each can be used.

D For the half cell involving the equilibrium between chlorine and chloride ions, a platinum electrode is used.

Your answer ☐

13 Which of the following statements relating to qualitative analysis is true?

1. Acid is added first, as fizzing identifies a compound as a carbonate or sulfate.
2. Silver nitrate is added last, as it gives a white precipitate with sulfates and chlorides, so sulfates need to be ruled out.
3. There is not a positive test for ammonium ions – they are identified by a process of elimination.

A 1 and 2 only

B 1 and 3 only

C 2 only

D 3 only

Your answer ☐

14 Which of the following statements are true?

1. A d orbital can hold up to two electrons.
2. The fourth shell has five p orbitals.
3. Electrons from the fourth shell get removed before the third shell when forming ions.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

Your answer ☐

15 Vanadium metal is used to increase the speed of the reaction between $SO_{2(g)}$ and $O_{2(g)}$, which forms $SO_{3(g)}$, while the vanadium is not used up. For this reaction $\Delta H = -196$ kJ mol^{-1}.

Which of the following is true?

1. The reaction uses a homogeneous catalyst.
2. The yield of sulfur trioxide decreases at higher pressure.
3. Higher temperatures cause the sulfur trioxide to form less quickly.

A 1 and 2 only

B 2 and 3 only

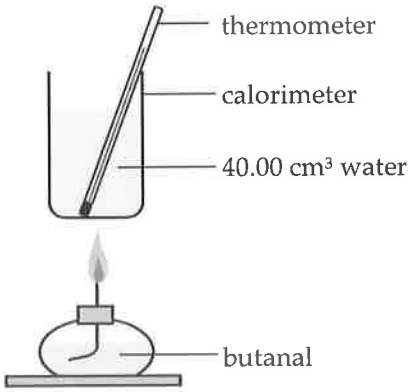
C 3 only

D None of the above are true

Your answer ☐

SECTION B

16 The enthalpy of combustion of butanal, C_4H_8O, may be determined using the apparatus below.



Start T (°C)	End T (°C)	Mass before (g)	Mass after (g)
17.0	59.0	53.80	53.57

- 40.00 cm^3 of water was measured into the calorimeter
- The spirit burner was weighed at the start
- The temperature of the water was recorded
- The burner was lit, and allowed to burn for two minutes, and then extinguished
- The temperature of the water was immediately recorded
- The burner was reweighed

a) Define 'standard enthalpy of combustion'.

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b) Calculate the number of moles of butanal burned.

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[1]

c) Calculate the energy change that occurred during the experiment, and hence the enthalpy of combustion of butanal. You may use the following data:

Specific heat capacity of water: 4.18 J g^{-1} K^{-1} Density of water: 1.00 g cm^{-3}

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[3]

d) The enthalpy of combustion of butanal to form carbon dioxide and water vapour can also be calculated using the enthalpy of vaporisation of water, +44 kJ mol^{-1}, and the following data from a textbook.

	C_4H_8O	CO_2	H_2O
ΔH°_f (kJ mol^{-1})	-245	-393	-286

Write an equation for the combustion of butanal, and determine a value for the enthalpy of combustion of butanal using this data.

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e) Apart from heat loss to the equipment and surroundings, and experimental errors such as incorrect measurement, identify one other reason why the experimental value gave a significantly different value to the value calculated using textbook data.

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f) The combustion of propanal, another aldehyde, is feasible at all temperatures. Explain what this means about the signs of ΔH and ΔS, and explain why propanal does not catch fire in air.

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[2]

QUESTION TOTAL: 12 MARKS

17 Before chlorine was produced via electrolysis reactions, it was produced using the Deacon process which involves the reaction of hydrogen chloride and oxygen as follows:

$$4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} + 2Cl_{2(g)}$$

a) If the process is used to produce 5.00×10^{-4} moles of chlorine, which is stored in a 2500 cm^3 container at 10.0 °C, what will the pressure in the container be in Pascals?

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[3]

b) 0.056 moles of $HCl_{(g)}$ and 0.0765 moles of $O_{2(g)}$ were mixed in a container at 298 K. At equilibrium, 0.0180 moles of $Cl_{2(g)}$ were found to be in the reaction vessel, and the pressure was 0.025 kPa. Calculate the value for K_p at this temperature.

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c) Give the unit for K_p for this equation.

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[1]

d) The chlorine produced can be used to make the compound sodium chlorate (V) $NaClO_3$.

i) Write a balanced equation for this process. (Note: $NaClO_3$ is not the only product.)

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[2]

ii) State what is meant by the term 'disproportionation' and explain why this reaction is an example of a disproportionation process.

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iii) A similar reaction makes NaClO. State a use for this compound.

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[1]

e) Iodine can perform many similar reactions to chlorine, including reactions where it acts as an oxidising agent.

i) Explain why these reactions usually proceed more slowly with iodine than with chlorine.

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ii)* Chlorine and iodine behave differently when added to the compound potassium bromide. Describe an experiment you would perform to confirm this, including any predicted observations and an explanation of what you would see. Support your answer with any relevant ionic equations.

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QUESTION TOTAL: 22 MARKS

18 Hydrogen chloride is a gas at room temperature that dissolves in water to form the important chemical hydrochloric acid.

a) i) Describe the structure of solid hydrogen chloride and explain why it forms a liquid and a gas at a much lower temperature than iodine monochloride (ICl).

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ii) Suggest why hydrogen chloride is much more soluble in water than chlorine, Cl_2.

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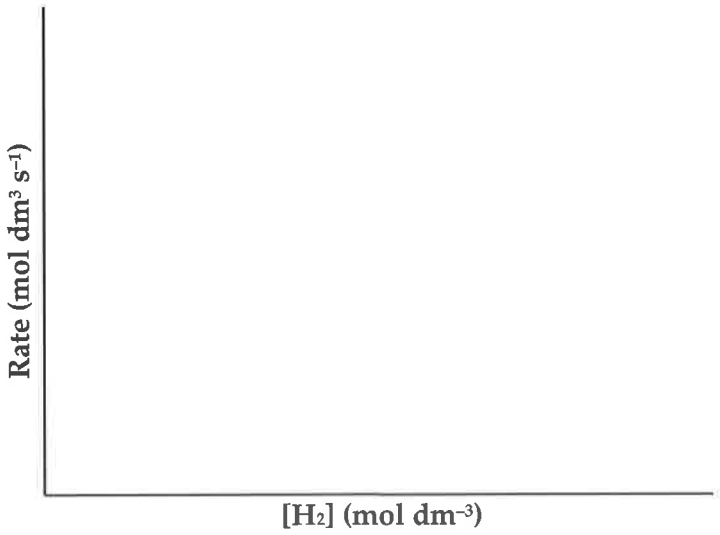
b) In the gaseous state, chlorine radicals react with hydrogen to generate hydrogen chloride and hydrogen radicals as follows:

$$Cl\bullet + H_2 \rightarrow HCl + H\bullet$$

The reaction was investigated at different temperatures and the rate constants, k, were determined. The table below gives the value for k at different temperatures.

T (K)		k (mol^{-1} dm^3 s^{-1})	
200		7.816×10^4	
300		7.877×10^6	
400		7.908×10^7	
500		3.160×10^8	
600		7.940×10^8	

i) The reaction is first order with respect to H_2. Sketch the shape of a rate against $[H_2]$ graph on the axes below.



[1]

ii) A plot of T against k cannot be used to work out the Arrhenius constant and the activation energy, but the information can easily be converted into data that can be plotted. Space has been left in the table above for you to do this.

Use the data above and the graph paper on the following page to plot a graph to work out a value for the activation energy, in kJ mol^{-1}, and the Arrhenius constant for this reaction.

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c) The reaction was repeated in the presence of a homogeneous catalyst

i) Explain what is meant by the term 'homogeneous' when describing a catalyst.

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ii) Describe how the graph would be different if a catalyst were added.

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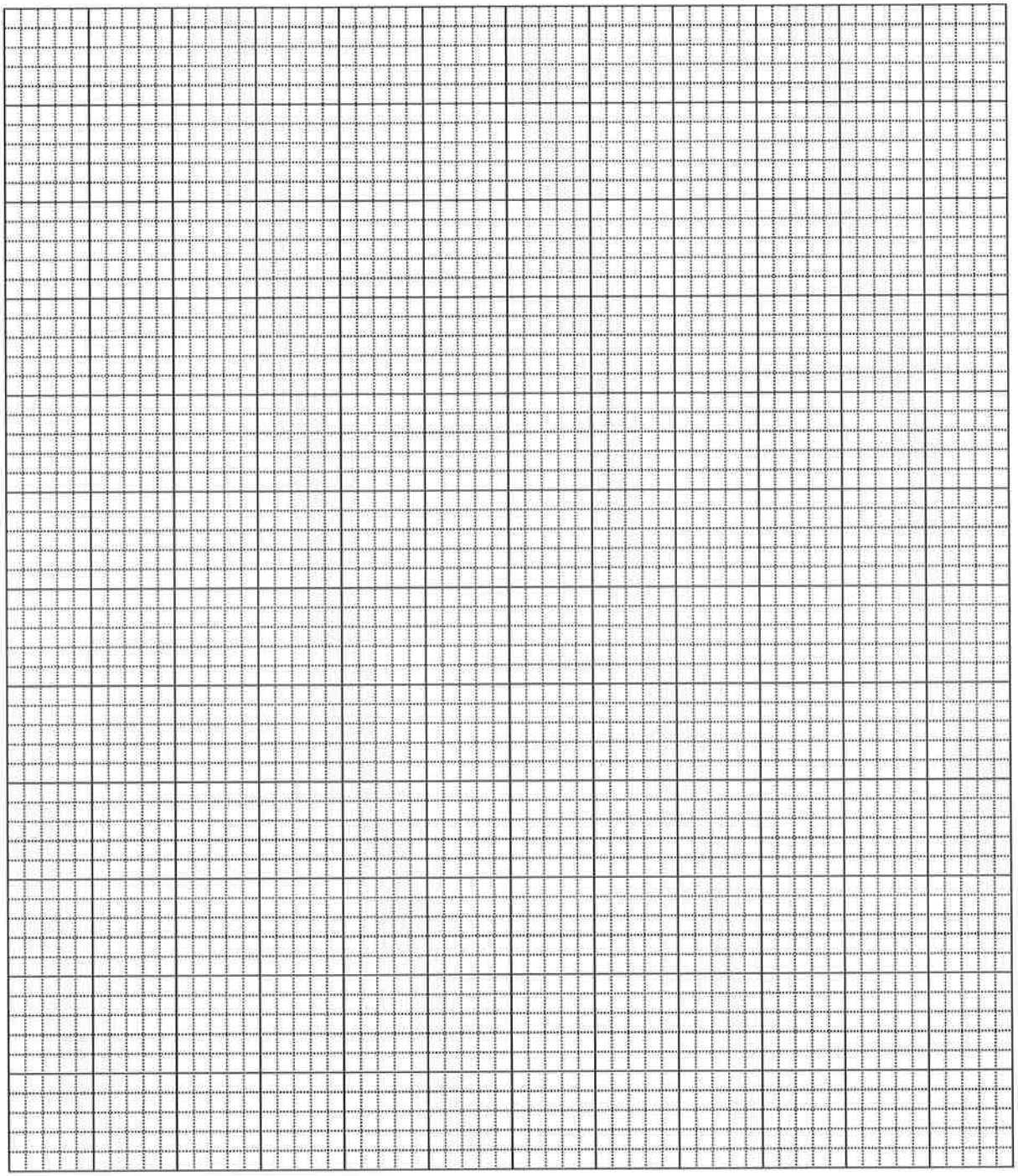
QUESTION TOTAL: 16 MARKS



19 O_2 can be used in fuel cells to power vehicles. Most oxygen molecules contain two ^{16}O atoms, but some may be made from other isotopes of oxygen.

a) i) Define the term 'relative isotopic mass'.

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(2)

ii) Complete the table to show the number of neutrons in each molecule of O_2.

Molecule	Number of neutrons
^{16}O–^{16}O	
^{18}O–^{16}O	
^{18}O–^{18}O	

(2)

b) Part of the relevant half equations and standard reduction potential are shown below for a methanol fuel cell in acidic conditions.

① $CO_{2(g)} \rightleftharpoons CH_3OH_{(l)}$ $E^{\ominus} =$ ____ V

② $O_{2(g)} \rightleftharpoons H_2O_{(l)}$ $E^{\ominus} = +0.40$ V

Rewrite the half cells for the equations shown above as **balanced** half equations, and use them to write an overall equation for the reaction of methanol and oxygen in a methanol fuel.

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c) i) Identify an advantage of a methanol fuel cell over a lithium electrochemical cell.

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ii) Suggest an advantage of a methanol fuel cell over a hydrogen fuel cell.

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d) The overall cell potential for the reaction in a methanol fuel cell is +1.21 V. Use this information to work out the theoretical standard reduction potential for equation ① above.

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(1)

QUESTION TOTAL: 11 MARKS

20 Chromium ions bring colour to many gemstones, including emeralds. In water, Cr^{3+} ions form the complex $[Cr(H_2O)_6]^{3+}_{(aq)}$, which can take part in many different reactions.

a) Define the term 'transition element'.

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[1]

b) Describe the bonding around chromium in the ion above.

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[2]

c) $[Cr(H_2O)_6]^{3+}$ can be reacted with an excess of ammonia.

i) Give the formula of the complex formed.

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[1]

ii) Identify the colour change that occurs.

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iii) Name the type of reaction occurring.

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[1]

d) The six water molecules around the chromium ion may be replaced when it is placed in a solution of the bidentate ligand $CH_3COCOCH_3$.

Assuming the coordination number of chromium remains the same, write an equation for this reaction.

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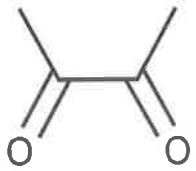
e) Explain, with the aid of diagrams, how the octahedral complex formed can exhibit optical isomerism.

You may represent the bidentate ligand as:



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QUESTION TOTAL: 13 MARKS

21 Phosphate-buffered saline (PBS) is an extremely important buffer used in medical sciences. It is non-toxic, and buffers to the pH levels in cellular environments, close to pH 7.

Phosphoric acid is a tribasic acid, H_3PO_4, but the species commonly used to make the buffer are KH_2PO_4 and the salt of its conjugate base, $KHPO_4^-$.

$$KH_2PO_4 \rightleftharpoons KHPO_4^- + H^+$$

a) Explain why phosphoric acid is a tribasic acid.

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[1]

b) Given that the pKa of KH2PO4 is 7.21, determine the concentration of KHPO4– needed to form a buffer with 0.100 mol dm–3 KH2PO4 that can be used to wash cells in a slightly alkaline solution of pH 7.40.

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[4]

c)* Carbonate buffers provide an alternative to phosphate buffers, and the carbonic acid / hydrogen carbonate buffer is the buffer found in blood. Describe the role of the carbonic acid / hydrogen carbonate buffer in blood plasma, explaining how it achieves this role in terms of equilibrium.

You should support your answer with chemical equations to illustrate the equilibrium involved. You do not need to discuss the formation of carbon dioxide from carbonic acid.

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[6]

QUESTION TOTAL: 11 MARKS

