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CANDIDATE NAME

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CHEMISTRY **0971/42**

Paper 4 Theory (Extended) **May/June 2026**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

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[Turn over

1 This question is about Group I and Group VII elements.

(a) Give the symbol of the element from Group I or Group VII which has:

(i) atoms with 11 protons

..... [1]

(ii) atoms with 35 electrons

..... [1]

(iii) molecules with an M_r of 254.

..... [1]

(b) Give the symbol of the element from Group I or Group VII which:

(i) is used to detect unsaturated hydrocarbon molecules

..... [1]

(ii) gives a lilac flame test

..... [1]

(iii) can displace aqueous bromide ions.

..... [1]

[Total: 6]

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2 Bonding is the attraction between particles. The particles can be atoms, molecules, ions or electrons.

(a) Bonding can be strong or weak.

(i) Complete Table 2.1 to describe the **strong** bonding in the substances shown.

Table 2.1

	sodium chloride	**bromine**	**magnesium**	**silicon(IV) oxide**
type of strong bonding	ionic	.....	.....	covalent
symbol of particle attracted	Na^+ and Cl^-	.....	..... and e^-	..... and .....
type of particle attracted	ions	.....	ions and electrons	.....

[7]

(ii) Name the **weak** attractions that are overcome when bromine boils.

..... [1]

(b) Sodium chloride and silicon(IV) oxide both have a lattice structure.

(i) Describe the arrangement of ions in sodium chloride.

.....

..... [2]

(ii) Name a substance that has a giant covalent lattice and similar properties to silicon(IV) oxide.

..... [1]

[Total: 11]

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3 The salt zinc sulfate is prepared by adding excess solid zinc carbonate to dilute sulfuric acid.

(a) Complete the equation for this reaction.

$$ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + \text{.....} + \text{.....}$$ [1]

(b) Name **one** other zinc compound that reacts with dilute sulfuric acid to produce zinc sulfate.

..... [1]

(c) The reaction is complete when no more zinc carbonate dissolves and a white solid of excess zinc carbonate is seen in the reaction mixture.

State **one** other observation which shows the reaction is complete.

..... [1]

(d) 200 cm^3 of solution **A** contains 30 g of dissolved $ZnSO_4$.

The maximum concentration of $ZnSO_4$ at room temperature is 60 g in 100 cm^3 of water.

(i) State the term used to describe a solution containing the maximum concentration of solute.

..... [1]

(ii) Water is allowed to evaporate from solution **A**.

Determine the volume of solution **A** when $ZnSO_4$ crystals first appear.

volume = ... cm^3 [1]

(iii) Solution **B** is formed when solution **A** is evaporated until 20 cm^3 remains.

Calculate the mass of $ZnSO_4$ that is formed from solution **B**.

mass = ... g [1]

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(e) Lead(II) sulfate, $PbSO_4$, is an insoluble salt which forms when an aqueous lead(II) salt reacts with an aqueous sulfate salt.

(i) Name a lead(II) salt and a sulfate salt that will form lead(II) sulfate.

lead(II) salt .....

sulfate salt ..... [2]

(ii) Name this technique of insoluble salt preparation.

..... [1]

(iii) Describe how pure lead(II) sulfate can be obtained from the reaction mixture.

.....

.....

..... [3]

(iv) Write the ionic equation for this reaction. Include state symbols.

..... [2]

(v) Name another insoluble sulfate salt that can be prepared by this method.

..... [1]

[Total: 15]

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4 Chromium, copper and nickel are transition elements.

(a) State **two** physical properties of transition elements that are different from Group I metals.

1 .....

2 .....
[2]

(b) Write the formulas of the following compounds of transition elements.

copper(I) oxide .....

nickel(II) nitrate .....
[2]

(c) Two ions that contain chromium are chromate(VI) ions, CrO_4^{2-}, and dichromate(VI) ions, $Cr_2O_7^{2-}$.

H^+(aq) ions convert CrO_4^{2-}(aq) ions to $Cr_2O_7^{2-}$(aq) ions. An equilibrium is reached.

$$2H^+(aq) + 2CrO_4^{2-}(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

chromate(VI) dichromate(VI)

(i) Explain why this is **not** a redox reaction.

..... [1]

(ii) Describe this equilibrium in terms of:

- the rate of the forward reaction and the rate of the reverse reaction

  .....

- the concentration of the reactants and of the products.

  .....
[2]

(iii) Explain why increasing the pressure has no effect on the position of equilibrium.

..... [1]

(iv) Explain why adding an alkali moves the position of equilibrium to the left.

.....

..... [2]

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(d) Transition elements form alloys.

(i) Name the alloy which is made by mixing copper with zinc.

..... [1]

(ii) Mixing chromium and nickel with iron and a non-metallic element makes a type of steel.

Name this type of steel and the non-metallic element used.

type of steel .....

non-metallic element .....
[2]

[Total: 13]

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5 This question is about compounds of nitrogen.

(a) Ammonia is manufactured by reacting hydrogen with nitrogen in the Haber process.

(i) State **one** source of hydrogen and **one** source of nitrogen.

hydrogen .....

nitrogen ..... [2]

(ii) Write the symbol equation for the reaction in the Haber process.

..... [2]

(iii) State the typical pressure, in kPa, used in the Haber process.

..... kPa [1]

(b) Aqueous ammonia, $NH_3(aq)$, is used to detect aqueous metal ions. The colour of the precipitate formed when $NH_3(aq)$ is added to an aqueous solution indicates the metal ion present.

(i) State the colour and give the name of the precipitate formed when $NH_3(aq)$ is added to $Cr^{3+}(aq)$ ions.

colour of precipitate .....

name of precipitate ..... [2]

(ii) When a few drops of $NH_3(aq)$ are added to $Zn^{2+}(aq)$ a white precipitate forms.

When a few drops of $Zn^{2+}(aq)$ are added to $NH_3(aq)$ no precipitate forms.

Explain these observations.

.....

.....

..... [2]

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(c) The reaction between ammonia and fluorine forms nitrogen trifluoride, $NF_3(g)$, and hydrogen fluoride, HF(g).

$$NH_3(g) + 3F_2(g) \rightleftharpoons NF_3(g) + 3HF(g) \qquad \Delta H = -870\,kJ/mol$$

(i) State how the equation shows this reaction is:

exothermic .....

reversible. .....

[2]

(ii) Figure 5.1 shows an incomplete reaction profile diagram for the forward reaction.

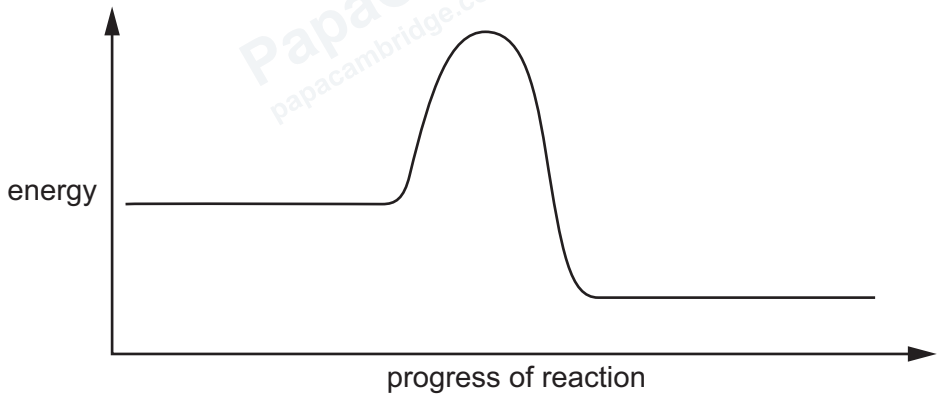

Figure 5.1

On Figure 5.1:

- write the formulas of the reactants and the products
- draw an arrow, labelled E_a, to show the activation energy
- draw an arrow, labelled ΔH, to show the enthalpy change.

[3]

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(iii) The equation for the forward reaction can be represented as shown.

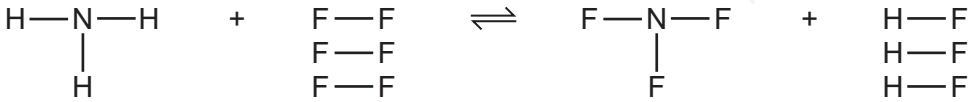

Table 5.1

bond	N–H	F–F	N–F
bond energy in kJ / mol	390	150	270

Use the bond energies in Table 5.1 and the ΔH value of –870 kJ / mol for the forward reaction to calculate the H–F bond energy. Use the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

- Calculate the total energy released when the bonds in the products form.

..... kJ

- Calculate the bond energy of the H–F bond.

..... kJ / mol
[4]

(d) On Figure 5.2, complete the dot-and-cross diagram of a molecule of nitrogen trifluoride.

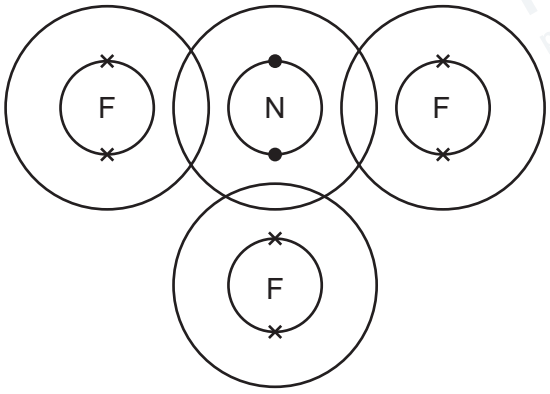

Figure 5.2

[3]

[Total: 21]

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6 Alcohols are a homologous series of organic compounds.

Table 6.1 gives some information about alcohols **A**, **B**, **C** and **D**.

Table 6.1

alcohol	A	B	C	D
number of carbon atoms	1	2	3	3
name	methanol	ethanol		
structural formula	CH_3OH	CH_3CH_2OH	$CH_3CH_2CH_2OH$	$CH_3CH(OH)CH_3$

(a) State why the homologous series of alcohols have similar chemical properties.

..... [1]

(b) Use information from Table 6.1 to answer the following questions.

(i) Deduce the number of electrons in a molecule of **A**.

..... [1]

(ii) State the molecular formula of **B**.

..... [1]

(iii) Name **C**.

..... [1]

(iv) Name **D**.

..... [1]

(c) The structural formula of **B**, CH_3CH_2OH, can also be written as C_2H_5OH.

Explain why the structural formula C_3H_7OH does **not** identify **C**.

..... [1]

(d) Ethanol is a fuel.

Write the symbol equation for the complete combustion of ethanol.

..... [2]

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(e) Ethanol can be oxidised by two methods.

method 1 Heating ethanol with an acidified aqueous oxidising agent.

method 2 The oxidation of ethanol using bacteria.

(i) Name the acidified aqueous oxidising agent used in **method 1**.

..... [1]

(ii) Give the chemical name of the organic product in **method 1**.

..... [1]

(iii) Name the food product in **method 2**.

..... [1]

(f) Alcohol **D** reacts with ethanoic acid in the presence of a catalyst to form ester **X** and one other product.

(i) Draw the displayed formula of ester **X**.

[2]

(ii) Name the other product formed.

..... [1]

[Total: 14]

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

Group

I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

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