Gold Paper
AS & A Level

Question Paper 3

Level	A Level
Subject	Chemistry
Exam Board	OCR
Paper	AS & A Level
Booklet	Question Paper 3

Time allowed: **84 minutes**

Score: **/62**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

The reversible reaction below is allowed to reach equilibrium.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9.4\,kJ\,mol^{-1}$$

Which change in conditions would be expected to shift the equilibrium position towards the products?

A. decrease the pressure

B. decrease the temperature

C. increase the pressure

D. increase the temperature

[1]

Which alcohol reacts with an acid catalyst to form *E* and *Z* stereoisomers?

A. pentan-3-ol

B. pentan-1-ol

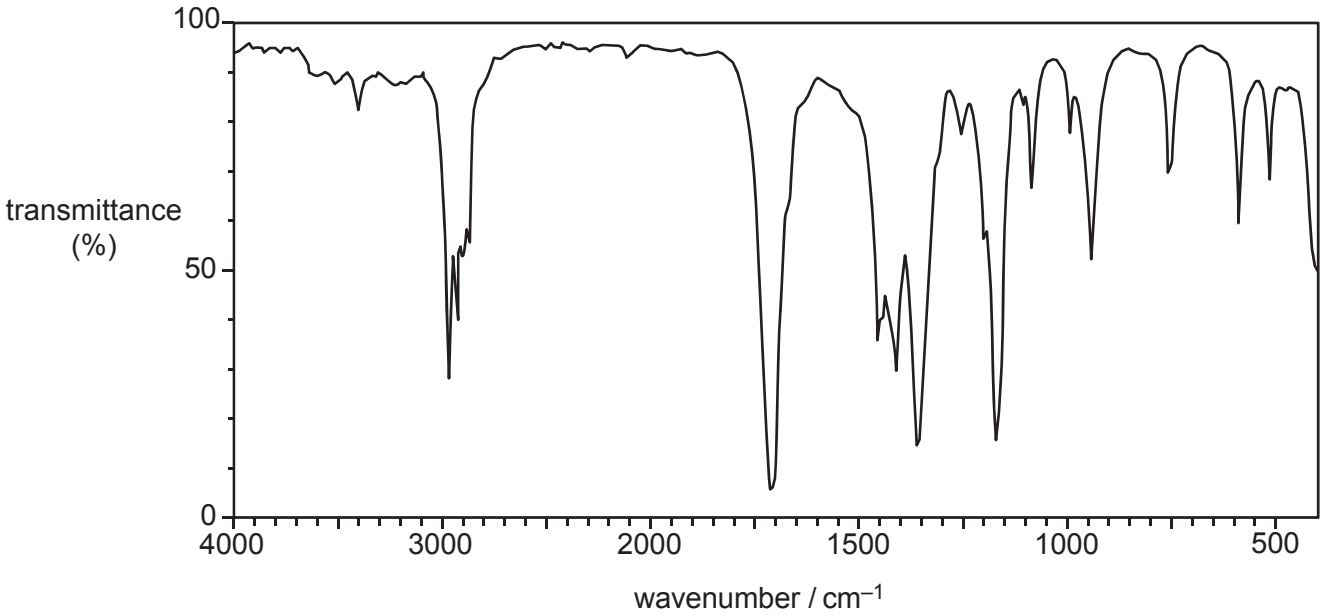
C. 2-methylbutan-2-ol

D. 2,2-dimethylpropan-1-ol

[1]

An alcohol **A** is heated under reflux with sulfuric acid and potassium dichromate(VI).

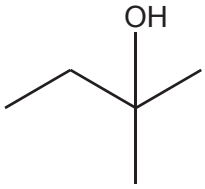
The organic compound formed produces the infrared spectrum below.



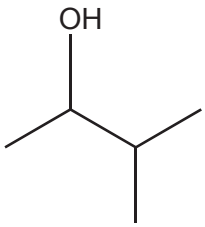
Which compound could be alcohol **A**?

[1]

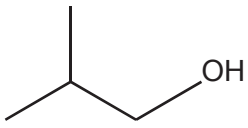
A



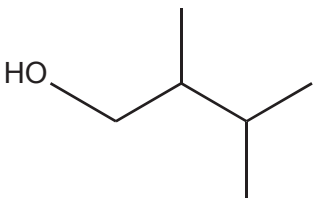
B



C



D



Which alcohol is **not** likely to have a fragment ion at $m/z = 43$ in its mass spectrum?

A. $CH_3CH_2CH(OH)CH_3$

B. $CH_3CH_2CH_2CH_2OH$

C. $CH_3CH(OH)CH_2CH_2CH_3$

D. $(CH_3)_2CHCH_2OH$

[1]

How many orbitals are occupied in a silicon atom?

A. 5

B. 7

C. 8

D. 9

[1]

This question is about enthalpy changes.

(a) **Table 16.1** shows enthalpy changes that can be used to determine the enthalpy change of hydration of fluoride ions, F^-.

Enthalpy change	Energy / kJ mol^{-1}
Hydration of Ca^{2+}	–1609
Solution of CaF_2	+13
Lattice enthalpy of CaF_2	–2630

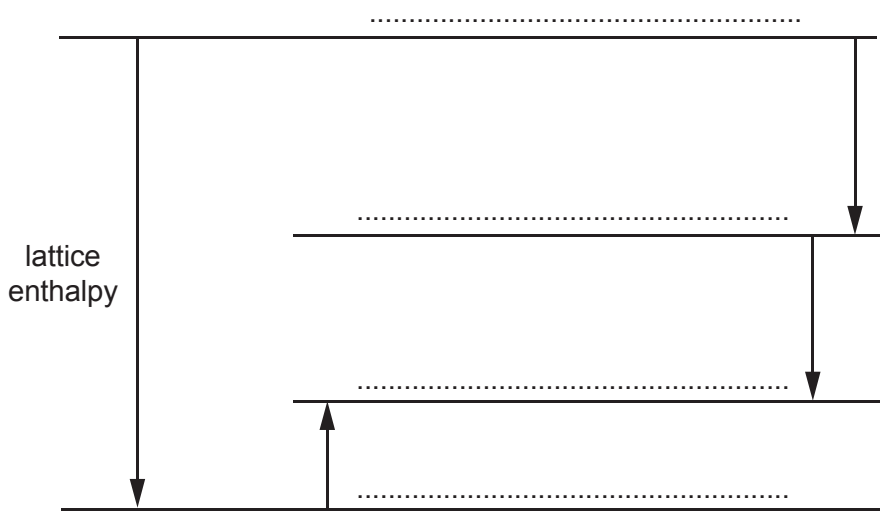
Table 16.1

(i) Explain what is meant by the term *enthalpy change of hydration*.

[2]

(ii) The enthalpy change of hydration of F^- can be determined using the enthalpy changes in **Table 16.1** and the incomplete energy cycle below.

On the dotted lines, add the species present, including state symbols.



[4]

(iii) Calculate the enthalpy change of hydration of fluoride ions, F^-.

[2]

(iv) Predict how the enthalpy changes of hydration of F^- and Cl^- would differ.

Explain your answer.

[2]

(b) Fluorine reacts with steam as shown in the equation below.

$$2F_2(g) + 2H_2O(g) \rightarrow O_2(g) + 4HF(g) \qquad \Delta H = -598\,kJ\,mol^{-1}$$

Average bond enthalpies are shown in the table.

Bond	Average bond enthalpy / kJ mol^{-1}
O–H	+464
O=O	+498
H–F	+568

(i) Explain what is meant by the term *average bond enthalpy*.

[2]

(ii) Calculate the bond enthalpy of the F–F bond.

[3]

(Total 15 marks)

This question is about compounds of magnesium and phosphorus.

(a) A student plans to prepare magnesium phosphate using the redox reaction of magnesium with phosphoric acid, H_3PO_4.

$$3Mg(s) + 2H_3PO_4(aq) \rightarrow Mg_3(PO_4)_2(s) + 3H_2(g)$$

(i) In terms of the number of electrons transferred, explain whether magnesium is being oxidised or reduced.

[1]

(ii) The student plans to add magnesium to 50.0 cm^3 of 1.24 $mol\,dm^{-3}$ H_3PO_4.

Calculate the mass of magnesium that the student should add to react exactly with the phosphoric acid.

Give your answer to **three** significant figures.

[3]

(iii) How could the student obtain a sample of magnesium phosphate after reacting magnesium with phosphoric acid?

[2]

(iv) Magnesium phosphate can also be prepared by reacting phosphoric acid with a compound of magnesium.

Choose a suitable magnesium compound for this preparation and write the equation for the reaction.

[2]

(b) Phosphine, PH_3, is a gas formed by heating phosphorous acid, H_3PO_3, in the absence of air.

$$4H_3PO_3(s) \rightarrow PH_3(g) + 3H_3PO_4(s)$$

(i) 3.20×10^{-2} mol of H_3PO_3 is completely decomposed by this reaction.

Calculate the volume of phosphine gas formed, in cm^3, at 100 kPa pressure and 200 °C.

[4]

(ii) When exposed to air, phosphine spontaneously ignites, forming P_4O_{10} and water.

Construct an equation for this reaction.

[1]

(Total 13 marks)

Nitrogen monoxide, NO, and hydrogen, H_2, react together.

The rate equation is shown below:

$$\text{rate} = k\,[NO(g)]^2\,[H_2(g)]$$

(a) What are the orders of reaction shown below?

Order with respect to NO(g):

Order with respect to $H_2(g)$:

Overall order of reaction: [1]

(b) Predict what would happen to the initial rate of the reaction between NO and H_2 for the following change in concentrations.

The concentrations of NO(g) and $H_2(g)$ are **both** increased by five times. [1]

(c) Nitrogen monoxide and hydrogen are reacted together. The initial concentrations and initial rate are shown below.

$[NO(g)]$ / mol dm^{-3}	3.24×10^{-3}
$[H_2(g)]$ / mol dm^{-3}	5.45×10^{-2}
initial rate / mol dm^{-3} s^{-1}	4.34×10^{-2}

Calculate the rate constant, *k*, for this reaction. State the units, if any.

Give your answer to **three** significant figures and in standard form. [3]

(d) Complete the table below to show the effect on the reaction rate and the rate constant, *k*, of the following changes in conditions.

Use the words **increases**, **decreases** or **none**.

Change	Effect on reaction rate	Effect on rate constant
Increase in pressure		
Increase in temperature		

[2]

(e) This reaction between NO(g) and $H_2(g)$ takes place by a two-step mechanism.

The rate equation is shown below:

$$\text{rate} = k\,[NO(g)]^2\,[H_2(g)]$$

- In the mechanism, step 1 is much slower than step 2.
- The equation for step 2 is shown below.

Write the equations for **step 1** and the **overall reaction**.

step 1

step 2: $H_2(g) + N_2O(g) \rightarrow N_2(g) + H_2O(g)$

overall reaction: [2]

[Total: 9 Marks]

Redox reactions are used in electrochemical cells and in analysis.

(a) **Table** 7.1 shows two redox systems, and their standard electrode potentials, $E^{\ominus}$.

	Redox system	$E^{\ominus}$/**V**
1	$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$	–0.74
2	$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77

Table 7.1

(i) A student sets up a standard cell in the laboratory based on redox systems 1 and 2.

Draw a labelled diagram to show how the student could set up this cell to measure its standard cell potential.

State the conditions needed to measure this standard cell potential. [4]

(ii) Write down the overall cell reaction. [1]

(iii) Write down the standard cell potential of this cell and state the sign of the chromium electrode.

[1]

(b) The student makes the following change to their standard cell set up in **(a)**.

The student adds solid $CrCl_3$ to the $Cr^{3+}(aq)$ / Cr(s) half-cell. The student stirs the solution to dissolve the $CrCl_3$.
The student finds that the cell potential has **decreased**.

Explain this observation, in terms of equilibrium and electrode potentials. [3]

(c) A new type of fuel cell has been developed based on HCOOH and O_2.

The equation for the overall cell reaction is shown below.

$$2HCOOH(l) + O_2(g) \rightarrow 2H_2O(l) + 2CO_2(g)$$

The half-equation at the oxygen electrode of this fuel cell is shown below.

$$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$$

(i) Deduce the half-equation at the other electrode of this fuel cell. [1]

(ii) Suggest **one** advantage of this fuel cell over a hydrogen fuel cell. [1]

(d) Redox reactions can be used in analysis.

Food additives containing sulfite ions, SO_3^{2-}, are often used as preservatives.

A student analyses a sample of hydrated sodium sulfite to find the formula of the hydrated salt.

The student titrates a solution of hydrated sodium sulfite with a standard solution of aqueous potassium manganate(VII), $KMnO_4$, under acidic conditions.

The method is outlined below.

- The student dissolves 2.400 g of hydrated sodium sulfite in water and makes the solution up to 250.0 cm^3.
- The student titrates 25.00 cm^3 volumes of this solution with 0.01500 mol dm^{-3} $KMnO_4$ under acidic conditions.

The mean titre is 25.40 cm^3.

In the titration, 2 mol of MnO_4^- reacts with 5 mol of SO_3^{2-}.

(i) Determine the formula of the hydrated sodium sulfite, showing clearly its water of crystallisation as a whole number.

[6]

(ii) In the titration, a redox reaction takes place between MnO_4^-, SO_3^{2-} and H^+ ions:

- MnO_4^- ions are reduced to manganese(II) ions,
- SO_3^{2-} ions are oxidised to sulfate(VI) ions.

Construct the overall equation for the redox reaction and the half-equations that take place in the titration.

Overall equation:

.

Half-equations:

[3]

[Total: 20 Marks]