

Chemistry
Standard level
Paper 2

Thursday 11 May 2017 (afternoon)

Candidate session number

1 hour 15 minutes

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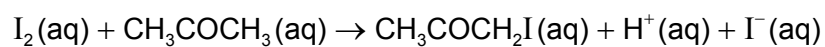
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



Answer **all** questions. Write your answers in the boxes provided.

1. The rate of the acid-catalysed iodination of propanone can be followed by measuring how the concentration of iodine changes with time.



- (a) (i) Suggest how the change of iodine concentration could be followed. [1]

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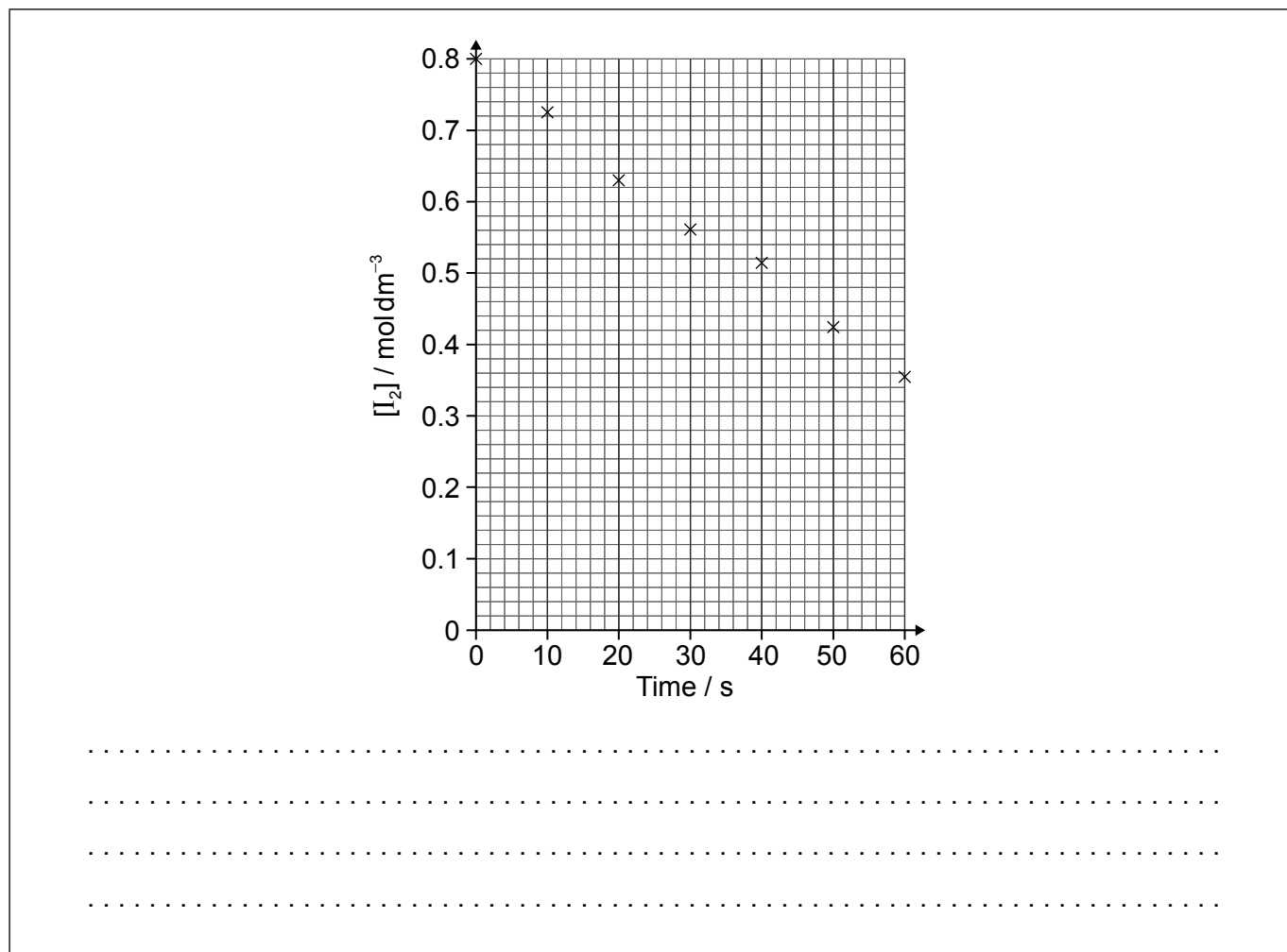


(Question 1 continued)

- (ii) A student produced these results with $[H^+] = 0.15 \text{ mol dm}^{-3}$. Propanone and acid were in excess and iodine was the limiting reagent.

Determine the relative rate of reaction when $[H^+] = 0.15 \text{ mol dm}^{-3}$.

[2]



(This question continues on the following page)



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Turn over

(Question 1 continued)

- (b) The student then carried out the experiment at other acid concentrations with all other conditions remaining unchanged.

$[H^+] / \text{mol dm}^{-3}$	Relative rate of reaction
0.05	0.0025
0.10	0.0051
0.20	0.0100

State and explain the relationship between the rate of reaction and the concentration of acid.

[2]

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2. Titanium is a transition metal.

- (a) Describe the bonding in metals.

[2]

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(Question 2 continued)

- (b) Titanium exists as several isotopes. The mass spectrum of a sample of titanium gave the following data:

Mass number	% abundance
46	7.98
47	7.32
48	73.99
49	5.46
50	5.25

Calculate the relative atomic mass of titanium to two decimal places. [2]

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- (c) State the number of protons, neutrons and electrons in the ${}^{48}_{22}\text{Ti}$ atom. [1]

Protons:

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Neutrons:

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Electrons:

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(Question 2 continued)

(d) (i) State the full electron configuration of the ${}_{22}^{48}\text{Ti}^{2+}$ ion. [1]

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(ii) Explain why an aluminium-titanium alloy is harder than pure aluminium. [2]

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(e) (i) State the type of bonding in potassium chloride which melts at 1043 K. [1]

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(ii) A chloride of titanium, TiCl_4 , melts at 248 K. Suggest why the melting point is so much lower than that of KCl. [1]

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(f) TiCl_4 reacts with water and the resulting titanium(IV) oxide can be used as a smoke screen.

(i) Formulate an equation for this reaction. [2]

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(Question 2 continued)

(ii) Suggest **one** disadvantage of using this smoke in an enclosed space. [1]

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3. Vanadium, another transition metal, has a number of different oxidation states.

(a) Determine the oxidation state of vanadium in each of the following species. [2]

V_2O_5 :
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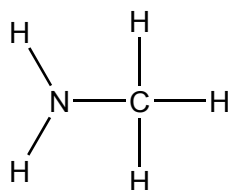
VO^{2+} :
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(b) Formulate an equation for the reaction between $VO^{2+}(aq)$ and $V^{2+}(aq)$ in acidic solution to form $V^{3+}(aq)$. [1]

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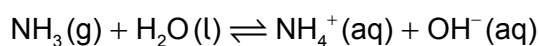
4. Two hydrides of nitrogen are ammonia and hydrazine, N_2H_4 . One derivative of ammonia is methanamine whose molecular structure is shown below.



(a) Estimate the H–N–H bond angle in methanamine using VSEPR theory. [1]

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(b) Ammonia reacts reversibly with water.



Explain the effect of adding $H^+(aq)$ ions on the position of the equilibrium. [2]

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(c) Hydrazine reacts with water in a similar way to ammonia. Deduce an equation for the reaction of hydrazine with water. [1]

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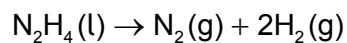
(Question 4 continued)

- (d) Outline, using an ionic equation, what is observed when magnesium powder is added to a solution of ammonium chloride.

[2]

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- (e) Hydrazine has been used as a rocket fuel. The propulsion reaction occurs in several stages but the overall reaction is:



Suggest why this fuel is suitable for use at high altitudes.

[1]

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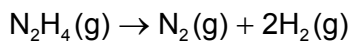
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(Question 4 continued)

- (f) Determine the enthalpy change of reaction, ΔH , in kJ, when 1.00 mol of gaseous hydrazine decomposes to its elements. Use bond enthalpy values in section 11 of the data booklet.

[3]



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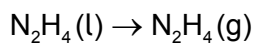
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- (g) The standard enthalpy of formation of $\text{N}_2\text{H}_4(\text{l})$ is $+50.6 \text{ kJ mol}^{-1}$. Calculate the enthalpy of vaporization, ΔH_{vap} , of hydrazine in kJ mol^{-1} .



(If you did not get an answer to (f), use -85 kJ but this is not the correct answer.)

[2]

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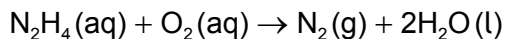
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16EP10

(Question 4 continued)

(h) Hydrazine is used to remove oxygen from water used to generate steam or hot water.



The concentration of dissolved oxygen in a sample of water is $8.0 \times 10^{-3} \text{ g dm}^{-3}$.

(i) Calculate, showing your working, the mass of hydrazine needed to remove all the dissolved oxygen from 1000 dm^3 of the sample. [3]

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(ii) Calculate the volume, in dm^3 , of nitrogen formed under SATP conditions. (The volume of 1 mol of gas = 24.8 dm^3 at SATP.) [1]

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5. This question is about carbon and chlorine compounds.

(a) Ethane, C_2H_6 , reacts with chlorine in sunlight. State the type of this reaction and the name of the mechanism by which it occurs. [1]

Type of reaction:
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Mechanism:
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(b) Formulate equations for the two propagation steps and one termination step in the formation of chloroethane from ethane. [3]

Two propagation steps:
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One termination step:
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(c) (i) One possible product, **X**, of the reaction of ethane with chlorine has the following composition by mass:

carbon: 24.27%, hydrogen: 4.08%, chlorine: 71.65%

Determine the empirical formula of the product. [2]

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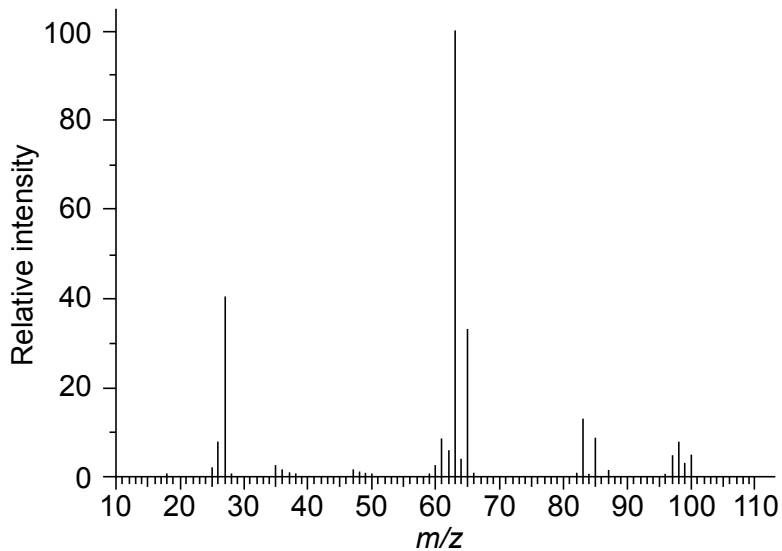


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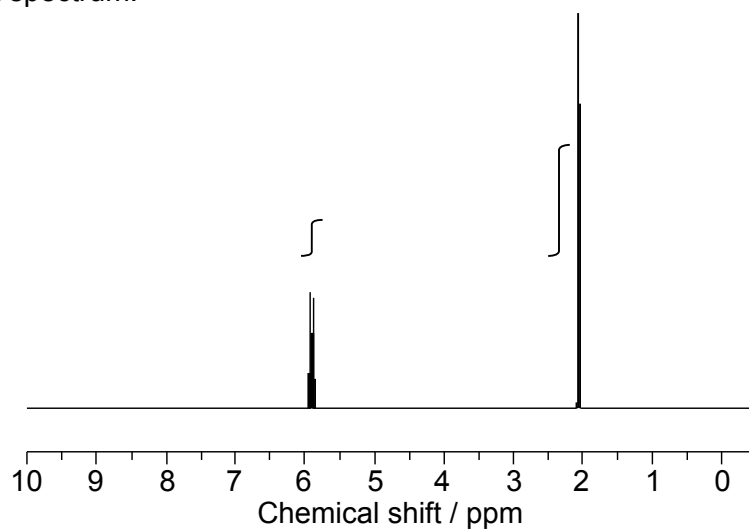
(Question 5 continued)

- (ii) The mass and ^1H NMR spectra of product **X** are shown below. Deduce, giving your reasons, its structural formula and hence the name of the compound. [3]

Mass spectrum:



^1H NMR spectrum:



[Source: <http://sdfs.db.aist.go.jp>]

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16EP13

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(Question 5 continued)

- (d) Chloroethene, C_2H_3Cl , can undergo polymerization. Draw a section of the polymer with three repeating units. [1]

6. Benzene is an aromatic hydrocarbon.

- (a) Discuss the physical evidence for the structure of benzene. [2]

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- (b) State the typical reactions that benzene and cyclohexene undergo with bromine. [1]

Benzene:

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Cyclohexene:

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16EP15

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16EP16