Catholic Junior College

JC1 Promotional Examinations

Higher 2

CANDIDATE NAME	
CLASS	**1T**

CHEMISTRY 9729/01 & 03

Paper 1 Multiple Choice (30 minutes) **Wednesday 2 October 2019**
Paper 3 Free Response (1 hour) **1 hour 30 minutes**

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not use staples, paper clips, glue or correction fluid.
Write and/or shade your name, NRIC / FIN number and class on the Multiple Choice Answer Sheet in the spaces provided.

For **Paper 1**, there are **fifteen** questions. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Multiple Choice Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

Multiple Choice Answer Sheet will be collected after the first 30 minutes.

For **Paper 3**, write your answers using the writing papers provided. Write in dark blue or black pen on both sides of the paper. Start each question on a fresh sheet of paper. You may use an HB pencil for any diagrams or graphs. The use of an approved scientific calculator is expected, where appropriate.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **11** printed pages and **1** blank page.

[Turn over

Paper 1

1 Which of the following statements is **not** true?

A One mole of water contains 2 moles of hydrogen atoms.

B One mole of chlorine gas contains 6.02×10^{23} chlorine atoms.

C One mole of ammonia has a mass of 17.0 g.

D One mole of sodium chloride contains 1.204×10^{24} ions.

2 In an experiment, 2 moles of an aqueous metallic salt reacted exactly with 1 mole of aqueous sodium sulfite, Na_2SO_3. The half-equation for oxidation of sulfite ion, SO_3^{2-} is shown below.

$$SO_3^{2-}(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$$

If the original oxidation number of the metal in the salt was +5, what would be the new oxidation number of the metal?

A +1 **B** +2 **C** +3 **D** +4

3 The first five successive ionisation energies of an element, **W**, found in Period 3, are as follows:

577, 1820, 2740, 11600, 14800 kJ mol^{-1}

Which statements are consistent with these data?

1 The outer electronic configuration of an atom of **W** is $3s^2 3p^1$.

2 There is a large increase between the 3rd and the 4th ionisation energy because the 4th electron is from an inner principal quantum shell.

3 **W** forms a chloride with a formula **W**Cl_4.

A 1 and 2 only **B** 2 and 3 only **C** 1, 2 and 3 **D** 1 only

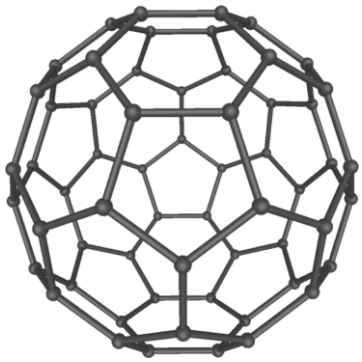
4 The Valence Shell Electron Pair Repulsion (VSEPR) theory is used to predict the shapes of molecules.

Which shape is correctly predicted by VSEPR theory?

	Number of bonded electron pairs around central atom	Number of lone pairs around central atom	Shape
A	2	1	linear
B	2	1	trigonal planar
C	3	1	tetrahedral
D	3	1	trigonal pyramidal

[Turn over

5 In 1985, a molecular form of carbon, C_{60}, called buckminsterfullerene, was discovered in the products formed when graphite was vapourised. It exhibits some properties similar to graphite. The structure proposed for the molecule is a roughly spherical collection of atoms in the shape of hexagons and pentagons, very much like a soccer ball.



Which one of the following properties is expected of buckminsterfullerene?

1 It burns completely in oxygen to give carbon dioxide gas only.

2 It has a lower melting point compared to graphite.

3 It dissolves in water.

A 1 only **B** 2 only **C** 1 and 2 only **D** 1, 2 and 3 only

6 Gases such as helium behave ideally under conditions of high temperature and low pressure.

Which of the following gases are very likely to behave ideally under the same conditions?

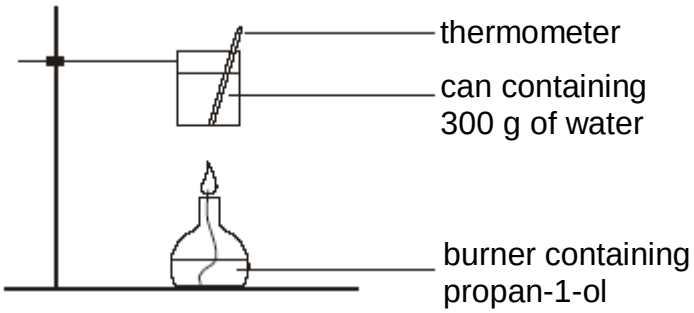
1 ammonia, NH_3

2 hydrogen, H_2

3 nitrogen, N_2

A 3 only **B** 1 and 2 only **C** 2 and 3 only **D** 1 and 3 only

7 A student used the apparatus below to heat a can containing 300 g of water.



The following data were recorded:

Mass of propan-1-ol burnt	= m g
Change in temperature of water	= ΔT °C

You are given that:

Relative molecular mass of propan-1-ol	= 60.0
Specific heat capacity of water	= c J g^{-1} K^{-1}

What is the enthalpy change of combustion, in kJ mol^{-1}, given that the process is 100 % efficient?

A $-\dfrac{m \times c \times \Delta T \times 60}{300}$

B $-\dfrac{m \times c \times \Delta T \times 60}{1000 \times 300}$

C $-\dfrac{300 \times c \times \Delta T \times 60}{1000 \times \text{m}}$

D $-\dfrac{300 \times c \times (\Delta T + 273) \times 60}{1000 \times m}$

8 Instant heat packs comprise a supersaturated solution of sodium ethanoate and a small flat disc of iron metal embedded in the solution. Pressing the disc will cause the following reaction to occur:

$$CH_3CO_2Na(aq) + 3H_2O(l) \rightarrow CH_3CO_2Na.3H_2O(s)$$

Which of the following reflects the correct signs of ΔH, ΔS and ΔG for the overall process of the reaction?

	ΔH	ΔS	ΔG
A	+	–	+
B	+	+	–
C	–	+	–
D	–	–	–

[Turn over

9 Acrylonitrile, CH_2=CHCN, is one of the toxic and cancer-causing chemicals that was illegally dumped into a river in Pasir Gudang in March 2019.

CH_2=CHCN is formed industrially in the following reaction:

$$CH_2{=}CHCH_3\,(g) + NH_3\,(g) + \frac{3}{2}O_2\,(g) \rightleftharpoons CH_2{=}CHCN\,(g) + 3H_2O\,(g) \qquad \Delta H = -519\ kJ\ mol^{-1}$$

Which of the following changes would increase the equilibrium constant, K_p?

A adding a suitable catalyst

B increasing the amount of NH_3 added

C increasing the pressure

D decreasing the temperature

10 The synthesis of ammonia gas by the Haber process is an important industrial method which leads to the production of artificial fertilisers for use in the cultivation of crops. The equilibrium reaction of the Haber Process is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Which of the following statements is true when the above equilibrium is subjected to a decrease in pressure?

1 The yield of NH_3 increases.

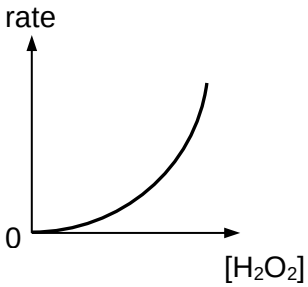
2 The amounts of N_2 and H_2 increase.

3 The value of K_c changes.

A 1 only **B** 1 and 2 only **C** 2 only **D** 2 and 3 only

11 The rate of decomposition of acidified hydrogen peroxide is found to be first order with respect to the concentration of hydrogen peroxide. Which graph correctly shows how the reaction rate changes with $[H_2O_2]$?

A



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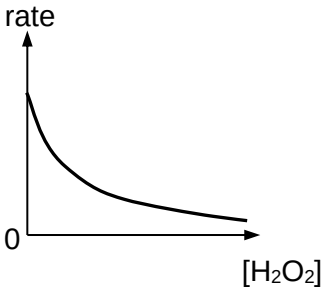

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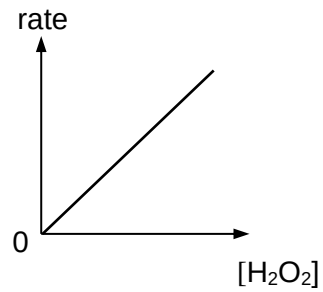
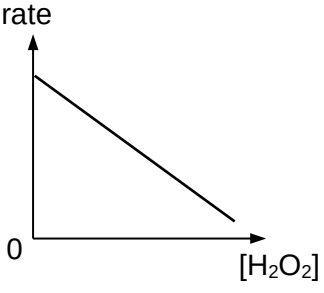


D



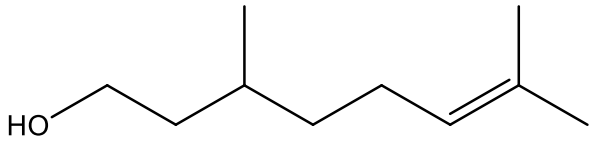
[Turn over

12 Constitutional (structural) isomers are compounds with the same molecular formula but different arrangement of atoms.

How many constitutional isomers with molecular formula $C_3H_6Br_2$ are there?

A 2 **B** 3 **C** 4 **D** 5

13 The given diagram shows the structure of citronellol, which is used in perfumes and insect repellents.



citronellol

What are the functional groups present in citronellol?

1 alkene

2 alcohol

3 carboxylic acid

A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

14 A catalytic converter is fitted into the exhaust system of a car for the purpose of removing toxic gases. Surfaces in a catalytic converter are coated with platinum and rhodium catalyst.

Which of the following reaction occurs in a catalytic converter?

A $CO_2 + NO \rightarrow CO + NO_2$

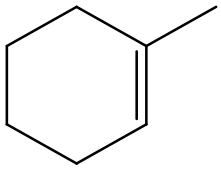
B $2CO + 2NO \rightarrow 2CO_2 + N_2$

C $2SO_2 + 2NO \rightarrow 2SO_3 + N_2$

D $C_8H_{18} + \frac{17}{2} O_2 \rightarrow 8CO + 9H_2O$

[Turn over

15 1-methylcyclohexene has the following structure:



1-methylcyclohexene

Which of the following statements is **false** about 1-methylcyclohexene?

A It can react with dilute $Br_2(aq)$.

B It can react with steam in the presence of concentrated phosphoric acid to form an alcohol.

C It can be reduced by hydrogen gas in the presence of nickel to form a cycloalkane.

D It can be oxidised by hot concentrated acidified $KMnO_4(aq)$ to form a diol.

Paper 3

Answer **all** the questions. Write your answers on the writing paper provided. Leave two lines between the answers to consecutive parts of the question. Start each question on a fresh sheet of paper.

You are advised to spend **not** more than 1 hour on this paper.

1 **(a)** Phosphorus forms many compounds with halides that are important industrial chemicals. Three of such phosphorus halides (PX_n) are phosphorus(III) chloride, PCl_3, phosphorus(III) bromide, PBr_3 and phosphorus(III) iodide, PI_3.

The following table shows physical data on these three compounds.

	PCl_3	**PBr_3**	**PI_3**
Relative molecular mass	137.5	270.7	411.7
P–X bond energy / kJ mol^{-1}	330	270	185
Boiling point / °C	76	176	200

Use the data above to explain the following trends down the group, from PCl_3 to PI_3.

(i) decreasing P–X bond energies [2]

(ii) increasing boiling points of PX_3 [3]

(b) Phosphorus(V) chloride, PCl_5, is another important phosphorus halide that is commonly used as a chlorinating agent in organic synthesis reactions.

In the gaseous phase, PCl_5 exists as discrete molecules.

(i) Explain why PCl_5 does not conduct electricity in the gaseous phase. [1]

In the solid crystalline phase, PCl_5 adopts an ionic structure, with the lattice consisting of two ions, PCl_4^+ and PCl_6^-.

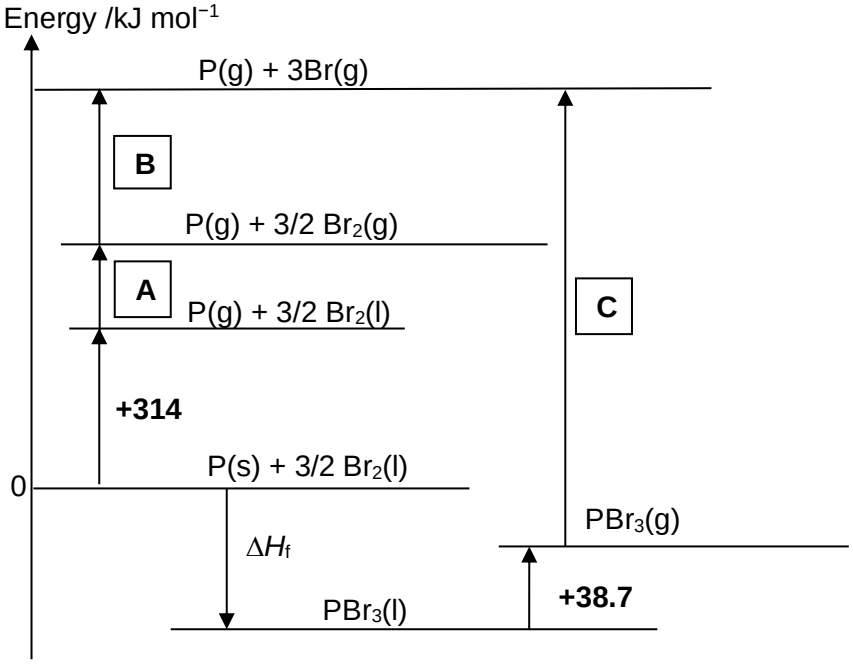
(ii) Draw the structures of these ions and use the Valence Shell Electron Pair Repulsion (VSEPR) theory to state their shapes and bond angles. [4]

[Turn over

(c) PBr_3 is a colourless liquid with a characteristic smell. It is formed when excess solid red phosphorus reacts with liquid bromine.

(i) An energy level diagram is shown below, that makes use of the bond energy data in **(a)**, the *Data Booklet* and the table below.

Enthalpy change of vaporisation of $PBr_3(l)$ / kJ mol^{-1}	+38.7
Enthalpy change of vaporisation of $Br_2(l)$ / kJ mol^{-1}	+31.0
Enthalpy change of atomisation of P(s) / kJ mol^{-1}	+314



Calculate the numerical values of the energy changes for **A**, **B** and **C** to complete the energy level diagram. [3]

(ii) Hence, use Hess' Law to determine the enthalpy change of formation for $PBr_3(l)$. [1]

(d) Ethanol, CH_3CH_2OH, which is a liquid, can be used as a source of fuel in place of hydrocarbons such as octane, C_8H_{18}.

(i) Define the term *standard enthalpy change of combustion* for ethanol. [1]

(ii) Write an equation, with state symbols, to represent the standard enthalpy change of combustion of ethanol. [1]

(iii) Given the following data below, calculate the heat produced by complete combustion of 1 dm^3 of each fuel. Hence, conclude which is a more efficient fuel based on the heat produced per dm^3 of fuel. [4]

	M_r	Density / g cm^{-3}	ΔH_c / kJ mol^{-1}
Ethanol	46.0	0.79	–1367
Octane	114.0	0.70	–5470

[Total: 20]

[Turn over

2 **(a)** State *Le Chatelier's Principle*. [1]

(b) In relation to the following equilibria,

Equilibrium 1 $2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$;

Equilibrium 2 $H_2O(g) + C(s) \rightleftharpoons H_2(g) + CO(g)$; ΔH = positive

use Le Chatelier's Principle to predict and explain the effect of

(i) increasing $[H^+(aq)]$ on *Equilibrium 1*, [1]

(ii) increasing the pressure on *Equilibrium 2*, [1]

(iii) decreasing the temperature on *Equilibrium 2.* [1]

(c) For *Equilibrium 3* below, when a 3:1 ratio of sulfur dioxide and oxygen at a total initial pressure of 4 atm is passed over a catalyst at a certain temperature, the partial pressure of sulfur trioxide at equilibrium is found to be 1.95 atm.

Equilibrium 3 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$; ΔH = negative

(i) Calculate the partial pressures of SO_2 and O_2 at equilibrium. [1]

(ii) Hence, determine the new total pressure, and by considering the initial partial pressure of SO_2, determine also the percentage conversion of SO_2 into SO_3. [2]

(iii) Write an expression for the equilibrium constant, K_p, and calculate its value. Include appropriate units for K_p in your answer. [2]

(iv) Any further increase in the partial pressure of SO_2 alone will not have a significant effect on the percentage conversion of SO_2 into SO_3. Suggest why this is so. [1]

[Turn over

(d) Hydrogen peroxide reacts with acidified iodide ions to liberate iodine according to the following equation:

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

The rate of reaction can be measured by tracking the increase in the concentration of iodine formed over time. The reaction was determined to be zero order with respect to hydrogen ions.

The following results were obtained by varying the concentrations of hydrogen peroxide and iodide ions.

Expt	Initial $[H_2O_2(aq)]$ / mol dm^{-3}	Initial $[I^-(aq)]$ / mol dm^{-3}	Initial rate / mol dm^{-3} min^{-1}
1	0.020	0.040	1.2×10^{-4}
2	0.020	0.080	2.4×10^{-4}
3	0.060	0.040	3.6×10^{-4}
4	0.050	1.000	7.5×10^{-3}

(i) Determine the order of reaction with respect to hydrogen peroxide and iodide ions, and write down the rate equation. [3]

(ii) Calculate the rate constant, stating its units. [1]

(iii) The reaction between hydrogen peroxide and iodide ions in acidic solution is considered to proceed via the following mechanism:

Step 1 $H_2O_2 + I^- \rightarrow IO^- + H_2O$

Step 2 $IO^- + H^+ \rightarrow HOI$

Step 3 $HOI + H^+ + I^- \rightarrow H_2O + I_2$

Based on your rate equation obtained in part **(d)(i)**, state and explain which of the three steps is the rate-determining step. [2]

(iv) Define the term *half-life*. [1]

(v) In Experiment 4, the concentration of iodide ions was much greater than that of hydrogen peroxide. State the implication that this has on the kinetics of the reaction. [1]

(vi) Sketch the shape of the graph of $[I^-]$ against time, clearly labelling the first two successive half-lives. You may use the symbols **t** to represent time, and $\mathbf{c_0}$ to represent the initial $[I^-]$. [2]

[Total: 20]

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