

NANYANG JUNIOR COLLEGE JC 2 PRELIMINARY EXAMINATION Higher 2

## CHEMISTRY

## 9729/01

Paper 1 Multiple Choice

21 September 2023

1 hour

Additional Materials:

Multiple Choice Answer Sheet Data Booklet

## READ THESE INSTRUCTIONS FIRST

Write in soft pencil. Do not use staples, paper clips, glue or correction fluid. Write your name, CT and NRIC / FIN on the Answer Sheet in the spaces provided.

There are **thirty** questions in this paper. 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 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. The use of an approved scientific calculator is expected, where appropriate. 1 When  $Tl^+(aq)$  ions are reacted with  $VO_3^-(aq)$  ions,  $Tl^{n+}(aq)$  ions and  $V^{2+}(aq)$  ions are formed.

Assuming the reaction goes to completion, 3 mol of  $Tl^+(aq)$  and 4 mol of  $VO_3^-(aq)$  would result in a mixture containing equal number of moles of  $VO_3^-(aq)$  and  $V^{2+}(aq)$ .

What is the value of n?

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

- 2 Two elements **E** and **G** have the following properties.
  - E and G form ionic compounds Na<sub>2</sub>E and Na<sub>2</sub>G with sodium respectively.
  - When reacted with fluorine, only **GF**<sub>6</sub> is formed but not **EF**<sub>6</sub>.

Which pair of electronic configurations of **E** and **G** is correct?

	E	G
Α	[He]2s <sup>2</sup> 2p <sup>4</sup>	[Ne]3s <sup>2</sup> 3p <sup>4</sup>
В	[He]2s <sup>2</sup> 2p <sup>2</sup>	[Ne]3s <sup>2</sup> 3p <sup>4</sup>
С	[Ne]3s <sup>2</sup> 3p <sup>4</sup>	[He]2s <sup>2</sup> 2p <sup>4</sup>
D	[Ne]3s <sup>2</sup> 3p <sup>4</sup>	[He]2s <sup>2</sup> 2p <sup>2</sup>

**3** A compound with an unknown central atom **J** has the following shape.



Which of the statements are correct about this compound?

- 1 There are 3 bond pairs and 1 lone pair around the central atom **J**.
- 2 There are a total of 10 electrons around the central atom J.
- 3 Element **J** is in Group 15 of the Periodic Table.
- 4 Element **J** is less electronegative than oxygen.
- A 1 and 2 only
- **B** 2, 3 and 4 only
- **C** 1, 2 and 4 only
- **D** 1, 3, and 4 only
- **4**  $BF_3$  reacts with  $(CH_3)_3N$  to give  $(CH_3)_3NBF_3$ . Which statement is correct?
  - **A**  $(CH_3)_3NBF_3$  contains hydrogen bonds.
  - **B** The B atom in  $(CH_3)_3NBF_3$  is not electron deficient.
  - C (CH<sub>3</sub>)<sub>3</sub>N is the Lewis acid while BF<sub>3</sub> is the Lewis base.
  - **D** N and B atoms in  $(CH_3)_3NBF_3$  are trigonal pyramidal and trigonal planar in shape respectively.

5 A given mass of a diatomic gas was placed in a vessel of fixed volume  $V \text{ cm}^3$  at a pressure p atm and temperature  $T^{\circ}C$ .

Assuming ideal behaviour, which of the following changes would cause the density of the gas to double?

- A Cooling the gas to  $\frac{1}{2} T \circ C$ .
- **B** Adding a catalyst that causes the gas to dissociate into gaseous atoms at  $T \circ C$ .
- **C** Adding an equal mass of the same gas into the same vessel at  $T \circ C$ .
- **D** Connecting the vessel to an identical vessel containing the same mass of the diatomic gas at  $T \circ C$  and p atm.

6 Use of the Data Booklet is relevant to this question.

An experiment was conducted to determine the efficiency of the heating of a can of water using a spirit burner.



You are given the following data:

change in temperature of water	= 15 °C
relative molecular mass of ethanol	= 46.0
enthalpy change of combustion of ethanol	= -1371 kJ mol <sup>-1</sup>
specific heat capacity of water	$= 4.18 \text{ J g}^{-1} \text{ K}^{-1}$

The efficiency of this heating process is 70%. Which expression below gives the mass of ethanol burnt?

Α	300 × 46.0 × 4.18 × 15 × 100
	70 × 1371 × 1000
В	70 × 4.18 × 15 × 46.0
	300 × 1371 × 1000 × 100
-	

- $\frac{300 \times 46.0 \times 4.18 \times 15 \times 1000}{70 \times 1371 \times 100}$
- $D \qquad \frac{70 \times 1371 \times 1000}{300 \times 4.18 \times 15 \times 46.0 \times 100}$

7 Hydrogen peroxide decomposes to form water and oxygen gas as shown in reaction 1.

reaction 1  $2H_2O_2(I) \rightarrow 2H_2O(I) + O_2(g)$ 

Given the following data at 298 K,

reaction 2	$O_2(g) + 2H_2(g) \rightarrow 2H_2O(I)$	$\Delta H_2^{\bullet} = a \text{ kJ mol}^{-1}; \Delta S_2^{\bullet} = b \text{ J mol}^{-1} \text{ K}^{-1}$
reaction 3	$O_2(q) + H_2(q) \rightarrow H_2O_2(l)$	$\Delta H_3^{\bullet} = c \text{ kJ mol}^{-1}; \Delta S_3^{\bullet} = d \text{ J mol}^{-1} \text{ K}^{-1}$

what is the value of  $\Delta G^{\circ}$ , in kJ mol<sup>-1</sup>, for reaction 1 at 298 K?

A 
$$(a-c) - 298(b-d)$$

**B** (a-2c)-298(b-2d)

**C** (a-c) - 0.298(b-d)

**D** 
$$(a-2c) - 0.298(b-2d)$$

8 A student performed an experiment to investigate a hypothetical reaction.

$$2\textbf{K} + \textbf{L} \rightarrow \textbf{M}$$

The graph of [K] against time for the experiment is plotted below.



Given that the units for the rate constant is mol<sup>-1</sup> dm<sup>3</sup> min<sup>-1</sup>, which statement is correct?

- **A** The reaction is elementary.
- **B** The gradient of tangent at t = 0 min increases by four times when initial [L] doubles.
- **C** The half-life of the reaction remains constant when a catalyst is added.
- **D** The half-life of this experiment remains constant when initial **[K]** doubles but halved when initial **[L]** doubles.

A student investigated the reaction between iodide ions and peroxydisulfate ions.

$$2I^{-}(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

In the first experiment, he added  $Fe^{3+}(aq)$  as catalyst. In the second experiment, he conducted the experiment under the same conditions but modified the experiment at  $t_1$ . The graphs of [I<sub>2</sub>] against time for both experiments are shown below.



Which statements are correct?

- 1 The rate of reaction at any given instant can be obtained from the graph.
- 2  $Fe^{3+}(aq)$  is used as a catalyst as it is able to exhibit variable oxidation states.
- 3 AgNO<sub>3</sub> could have been added at  $t_1$ .
- 4 The Boltzmann distribution graph for the first experiment is as follows.



**10** 2.0 mol of NO<sub>2</sub> dimerises to form  $N_2O_4$ . The reaction was carried out in a 1 dm<sup>3</sup> sealed tube. The graph below shows the Gibbs free energy change during the reaction.



Which statements are correct?

- 1  $\Delta H^{\circ}$  has a negative value.
- 2 The equilibrium constant,  $K_c$ , is 1.66 mol<sup>-1</sup> dm<sup>3</sup>.
- 3 The forward reaction is more spontaneous at low temperature.
- 4 When the reaction is repeated under the same conditions with 0.3 mol of NO<sub>2</sub> and 0.85 mol of  $N_2O_4$  in 1 dm<sup>3</sup> sealed tube, the position of equilibrium shifts to the right.

Α	1 and 3 only	В	1, 2 and 3 only
	5		, ,

**C** 2, 3 and 4 only **D** 1, 2, 3 and 4

**11** When 25 cm<sup>3</sup> of aqueous HC*l* is titrated against aqueous  $CH_3CH_2NH_2$  of the same concentration, the following pH curve was obtained.



At which point will the mixture achieve maximum buffering capacity?

**12** The pH of pure water is 6.88 at 32 °C. The pH of a saturated solution of a Group 2 hydroxide is 11.70 at the same temperature.

What is the value of the solubility product of this hydroxide at 32 °C?

Α	6.3 x	$10^{-8}$
	0.0 /	

- **B** 3.3 x 10<sup>-7</sup>
- **C** 1.3 x 10<sup>−5</sup>
- **D** 3.8 x 10<sup>-5</sup>

**13** Silicon is an element in the third period of the Periodic Table.

Which statement is correct for silicon but not the other elements in this period?

- A Silicon is the only element in this period which forms an oxide which is insoluble in water.
- **B** Silicon is the only element in this period which forms an oxide via covalent bonds with oxygen atoms.
- **C** Silicon is the only element in this period whose chlorides undergoes hydrolysis to give a highly acidic solution (pH  $\approx 1 2$ ).
- **D** Silicon is the only element in this period whose chlorides undergoes hydrolysis in water to give 4 moles of HC*l* gas.
- 14 Use of the Data Booklet is relevant to this question.

The ash from burnt seaweed contains chlorides and iodides of some Group 1 and Group 2 elements. Some seaweed ash was treated with hydrogen peroxide in an alkaline medium and aqueous silver nitrate is added to the resulting solution.

	with alkaline hydrogen peroxide	with aqueous silver nitrate	
Α	black deposit	white precipitate	
В	black deposit	yellow precipitate	
С	no deposit	white precipitate	
D	no deposit	yellow precipitate	

What would be observed during the experiment?

- 15 Which statement about benzene and cyclohexene is correct?
  - **A** Benzene and cyclohexene have delocalised  $\pi$  electrons.
  - **B** Benzene and cyclohexene decolourises aqueous bromine in the presence of finely divided iron.
  - **C** Benzene is less susceptible towards electrophilic attack than cyclohexene.
  - **D** Benzene and cyclohexene are planar molecules.

- 16 An unknown compound has the following features.
  - It is non-cyclic.
  - It has a relative molecular mass of x.
  - It produces a silver mirror with Tollens' reagent.
  - It reacts with  $H_2$  in the presence of Ni to form a product with the molecular mass of (x + 4).

What is the smallest possible value of the molecular mass, x?

<b>A</b> 54 <b>B</b> 56 <b>C</b> 58	<b>D</b> 60
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17 Compound **Q** reacts with acidified hot concentrated manganate(VII) ions.



How many stereoisomers and oxygen atoms will be present in the organic product(s) formed?

	no. of stereoisomers	no. of oxygen atoms
Α	2 <sup>2</sup>	5
В	2 <sup>2</sup>	6
С	2 <sup>3</sup>	5
D	2 <sup>3</sup>	6

**18** In which reaction does a carbon atom change from being sp<sup>3</sup> hybridised in the intermediate to being sp<sup>2</sup> hybridised in the product?



**19** During the synthesis of many organic compounds, by-products are formed.

An ether is produced via the reaction scheme.



- **20** A catalytic converter is part of the exhaust system of many modern cars. Which reactions occur in a catalytic converter?
  - $1 \quad 2CO + 2NO \rightarrow 2CO_2 + N_2$
  - $2 \quad 2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$
  - $3 \quad \text{CO}_2 + \text{NO} \rightarrow \text{CO} + \text{NO}_2$

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

21 Which statements are correct about the compound below?



- 1 It reacts with H<sub>2</sub> in the presence of Pt catalyst to incorporate six hydrogen atoms into the compound.
- 2 It reacts with LiA/H<sub>4</sub> in dry ether to produce an organic compound containing one primary amine group.
- 3 It reacts with NaBH<sub>4</sub> to produce an organic compound containing one secondary alcohol group.
- A 1 and 2 only B 2 and 3 only C 1 only D 3 only

$$H_2C = CH_2 + 1/2 O_2 \xrightarrow{\text{catalyst}} CH_3CHC$$

The aldehydes and ketones will subsequently react with alcohols in an acid catalysed reaction to form a product containing two –OR groups bonded to the same carbon.



Compound **R** undergoes catalytic oxidation, followed by an acid catalysed reaction with  $HOCH_2CH_2OH$  to produce the following as the only product.



Which of the following best represents the structure of R?



23 One mole of compound **T** is warmed with excess ethanolic silver nitrate. How many moles of silver chloride will be precipitated?



- **24** Compound **U**,  $C_{13}H_{13}O_4Br$ , undergoes the following reactions.
  - 1 mol of U reacts with Tollens' reagent, but not Fehling's solution, to produce 4 mol of silver.
  - U reacts with hot ethanolic sodium hydroxide to form 3 isomeric products.
  - **U** reacts with hot acidified potassium dichromate(VI) to form two organic compounds.

What is the structure of **U**?



**25** A carboxylic acid, **V**, has no possible chain isomers. It reacts with an alcohol, **W**, that has only one other positional isomer.

What could be the ester formed from a reaction between V and W?

- **A** butyl propanoate
- **B** ethyl butanoate
- **C** pentyl ethanoate
- **D** propyl pentanoate
- 26 Compound X contains only carbon, hydrogen and oxygen. It gives an orange precipitate with 2,4-dinitrophenylhydrazine. When compound X is heated with aluminium oxide, compound Y is the only organic compound formed. 1 mol of compound Y reacts with only 1 mol of aqueous bromine and also reacts with hot acidified potassium manganate(VII) to give no organic product.

Which functional groups can be found in X?

- 1 aldehyde
- 2 ketone
- 3 primary alcohol
- 4 tertiary alcohol
- **A** 1 and 3 only **B** 1 and 4 only **C** 2 and 3 only **D** 2 and 4 only
- **27** Which statement about the relative basicity of methylamine, dimethylamine and trimethylamine in the gas phase is correct?
  - A The lone pair of electrons on the nitrogen atom of trimethylamine delocalises over three methyl groups, making trimethylamine the most basic.
  - **B** Three electron-withdrawing methyl groups increase the electron density of the nitrogen atom of trimethylamine, making trimethylamine the most basic.
  - **C** The lone pair of electrons on the nitrogen atom of trimethylamine is the most available for donation, making trimethylamine the strongest Lewis base.
  - **D** Three methyl groups disperse the negative charge on the nitrogen atom of trimethylamine, making trimethylamine the strongest Bronsted base.
- **28** An electrochemical cell was set up between magnesium and an unknown Group 2 metal, **Z**. The overall equation is shown below.

 $Z(s) + Mg^{2+}(aq) \rightarrow Z^{2+}(aq) + Mg(s)$ 

Given that the standard Gibbs free energy change of the reaction is  $-100 \text{ kJ mol}^{-1}$ , which of the following statements are correct?

- 1 The atomic radius of **Z** is smaller than Mg.
- 2 The standard electrode potential for  $Z^{2+}/Z$  half cell is -2.90 V.
- 3 In the salt bridge, the cations migrate to the Mg<sup>2+</sup>/Mg half cell while the anions migrate to the **Z**<sup>2+</sup>/**Z** half cell.
- 4 When NaOH(s) is added to Mg<sup>2+</sup>/Mg half cell, the standard Gibbs free energy change of the reaction becomes more negative.
- A 1 and 2 only
- **B** 2 and 3 only
- **C** 1, 3 and 4 only
- **D** 2, 3 and 4 only
- **29** Two cells, one containing a molten chloride of manganese and the other containing molten chromium(III) chloride, were connected in series. 33.0g of manganese and 20.8g of chromium were produced. What is the oxidation state of manganese in the molten manganese chloride?

A ·	+2	В	+3	С	+4	D	+5
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**30** The following shows iron(III) ions in two different reactions.

reaction 1:  $[Fe(H_2O)_6]^{3+}(aq) + H_2O(I) \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+}(aq) + H_3O^+(aq)$ reaction 2:  $[Fe(H_2O)_6]^{3+}(aq) + 3H_2NCH_2CH_2NH_2(aq) \rightleftharpoons [Fe(H_2NCH_2CH_2NH_2)_3]^{3+}(aq) + 6H_2O(I)$ Which statements are correct?

1 Both reactions are ligand exchange reactions.

- 2 The entropy change,  $\Delta S$ , for reaction 2 is negative.
- 3 The geometry about Fe in  $[Fe(H_2NCH_2CH_2NH_2)_3]^{3+}$  is the same as that in  $[Fe(H_2O)_5(OH)]^{2+}$ .
- A 1, 2 and 3 B 1 and 2 only C 2 and 3 only D 3 only