

RAFFLES INSTITUTION 2021 YEAR 6 PRELIMINARY EXAMINATION

Higher 2

CHEMISTRY

Paper 1 Multiple Choice

Additional Materials:

Multiple Choice Answer Sheet Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not open this question booklet until you are told to do so.

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid. Write your name, class and index number in the spaces provided on the Answer Sheet.

There are **thirty** questions on 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 the question booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of 15 printed pages.



1 hour

1 The shape of each p-orbital is represented as two lobes.

How many electrons does Cu have in orbitals with four lobes?

- **A** 7 **B** 8 **C** 9 **D** 10
- **2** Use of the Data Booklet is relevant to this question.

lonisation energy generally increases across a period. In Period 2, there are two irregularities which cause ionisation energy to be lower than expected.

The graph below shows the 2nd ionisation energies of four consecutive elements with atomic numbers less than 20.



What is a possible identity of K?

- 1 boron
- 2 carbon
- 3 oxygen
- 4 fluorine
- A 1 and 3
- **B** 2 and 4
- **C** 1 only
- D 2 only

- It is non-volatile.
- It does not conduct electricity in its standard state.
- It dissolves in water.

What is the identity of **Q**?

- A nitrogen dioxide
- **B** silicon dioxide
- **C** sodium
- D sodium oxide
- **4** Beryllium is diagonal to aluminium in the Periodic Table and they share similar properties.

Which structures for the compounds of beryllium and fluorine are possible?



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

5 X, Y and Z are elements in the third period of the Periodic Table. The oxide of X is amphoteric, the oxide of Y is basic and the oxide of Z is acidic.

What is the order of increasing ionic radius for these three elements?

- A
 X < Y < Z</th>

 B
 X < Z < Y</th>

 C
 Y < X < Z</th>
- D Y < Z < X

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

Which metal ion has the highest K_a ?

- **A** [Co(H₂O)₆]³⁺
- **B** $[Mg(H_2O)_6]^{2+}$
- **C** $[Mn(H_2O)_6]^{2+}$
- **D** $[V(H_2O)_6]^{3+}$
- **7** The volumes and pressures of equal masses of four gases CH₃OH, SiH₄, HBr, and H₂Se, are separately investigated, at constant temperature. The results are plotted on a graph of pV against p.

Which plot shows the results for CH₃OH?



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

Which halogen will not oxidise Fe²⁺ to Fe³⁺?

 9 N₂O₅ is a compound involved in important atmospheric reactions, such as ozone depletion. It may be formed from N₂ and O₂ during electric discharge.

Given the following data, what is the ΔH_{f} of N₂O₅(g)?

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$	$\Delta H = -114.1 \text{ kJ mol}^{-1}$
$4NO_2(g) + O_2(g) \longrightarrow 2N_2O_5(g)$	$\Delta H = -110.2 \text{ kJ mol}^{-1}$
$N_2(g) + O_2(g) \longrightarrow 2NO(g)$	ΔH = +180.5 kJ mol ⁻¹

- A –43.8 kJ mol⁻¹
- **B** –21.9 kJ mol⁻¹
- C +11.3 kJ mol⁻¹
- **D** +22.6 kJ mol⁻¹

10 The Haber process involves the following reaction in the presence of an iron catalyst.

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

Which graph shows the effect of increasing partial pressure of $N_2(g)$, p_{N_2} , on the initial rate of reaction?



[Turn Over

11 The reaction in a light stick involves the following reaction.



The reaction is first order with respect to the concentrations of both H_2O_2 and compound **P**. In a prototype light stick, where H_2O_2 is present in large excess, it was found that the concentration of compound **P** decreases to 25% of its initial concentration in 1 hour.

What is the half-life of the reaction above?

- A 15 minutes
- B 30 minutes
- **C** 45 minutes
- **D** 60 minutes
- 12 Ozone decomposes naturally into oxygen according to the following equation.

$$2O_3 \longrightarrow 3O_2$$

The following mechanism has been proposed.

step 1	$O_3 \Longrightarrow O + O_2$	fast
step 2	$^{\bullet}O + O_3 \longrightarrow 2O_2$	slow

 K_1 is the equilibrium constant of step 1 and k_2 is the rate constant of step 2.

Which statements are correct for this reaction?

- 1 The order of reaction with respect to [O₃] is 2.
- 2 The overall rate equation is rate = $k_2 K_1 \frac{[O_3]^2}{[O_2]}$.
- 3 Increasing [O₂] slows down the reaction.
- **A** 1, 2 and 3
- **B** 1 and 3 only
- C 1 only
- D 2 only

13 The Contact process for producing sulfuric acid involves the following reaction.

$$V_2O_5(s)$$
catalyst
$$2SO_2(g) + O_2(g) \xrightarrow{\qquad} 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

The process is carried out at 450 °C and 2 atm.

Which statements are correct?

- 1 At high temperature, more reactant particles have energy higher than the activation energy, thus the rate of production is faster.
- 2 At high temperature, more reactant particles have energy higher than the activation energy, thus a greater yield is obtained.
- 3 At high pressure, the rate constant of the reaction is greater, thus the rate of production is faster.
- 4 The presence of a catalyst increases the rate constant of the reaction, thus the rate of production is faster.
- A 1, 2 and 3
- **B** 1, 3 and 4
- **C** 1 and 4 only
- **D** 2 and 4 only
- **14** A particular reaction is endothermic. At high temperature, the ratio of $\frac{[products]}{[reactants]}$ at equilibrium is lower than 1.

Which graph represents how ΔG^{\ominus} changes with temperature for the reaction?



15 The value of the ionic product of water, K_w is affected by temperature.

temperature / K	<i>K</i> _w / 10 ⁻¹⁴ mol ² dm ⁻⁶
293	0.681
303	1.47

Which statement is correct?

- A Water is less acidic at 293 K than at 303 K.
- **B** The enthalpy change of ionisation of water is exothermic.
- **C** The number of molecules in water increases from 293 K to 303 K.
- **D** The concentration of hydroxide ions in water increases from 293 K to 303 K.
- 16 What is the order of decreasing pK_a for these isomers?



- A P > R > Q
- **B Q** > **P** > **R**
- C R > P > Q
- $\mathsf{D} \qquad \mathsf{R} > \mathsf{Q} > \mathsf{P}$
- **17** A buffer is considered effective in resisting pH changes when the difference between its pH and pK_a is not more than 1.

A mixture was prepared by mixing 30 cm³ of a 1 mol dm⁻³ solution of NaOH with 35 cm³ of a 1 mol dm⁻³ solution of ethanoic acid. (K_a of ethanoic acid = 1.8 × 10⁻⁵ mol dm⁻³)

Which statements are correct?

- 1 The pH of the mixture is 4.74.
- 2 The mixture can act as an effective buffer.
- 3 The mixture can better resist pH changes when a small amount of alkali is added than when a small amount of acid is added.
- **A** 1, 2 and 3
- **B** 2 and 3 only
- C 2 only
- D 3 only

18 In a saturated aqueous solution of mercury(I) bromide, Hg₂Br₂, the following equilibrium exists.

$$Hg_2Br_2(s) \rightleftharpoons Hg_2^{2+}(aq) + 2Br^{-}(aq)$$

Given that the numerical value of the solubility product of mercury(I) bromide is 6.4×10^{-23} , what is the solubility of mercury(I) bromide?

- A $2.52 \times 10^{-8} \text{ mol dm}^{-3}$
- ${\bm B} \qquad 4.00 \times 10^{-8} \ mol \ dm^{-3}$
- $\label{eq:constraint} \bm{C} \qquad 5.66 \times 10^{-12} \ mol \ dm^{-3}$
- **D** $8.00 \times 10^{-12} \text{ mol dm}^{-3}$
- **19** How many σ bonds and π electrons does the molecule below have?



	σ bond	π electron
Α	12	6
В	12	8
С	17	6
D	17	8

20 Which set of reagents and conditions can be used in the synthesis below?



	step 1	step 2	step 3
Α	KCN, H ₂ SO ₄ (aq)	SOCl ₂ , anhydrous	HCl(aq), heat
В	HCN, trace KOH	HC <i>l</i> (aq), heat	PCl ₃ , anhydrous
С	ethanolic KCN, heat	NaBH ₄	SOCl ₂ , anhydrous
D	NaBH ₄	ethanolic KCN, heat	HC <i>l</i> (aq), heat

21 Compound **U** undergoes substitution with chlorine gas to form monosubstituted compounds.



How many possible isomers, including stereoisomers, can be formed in the reaction?



22 Which reagents and conditions can be used to distinguish between compounds V and W?



- A Na₂CO₃(aq)
- **B** hot acidified KMnO₄(aq)
- **c** neutral FeC*l*₃(aq)
- **D** $Br_2(aq)$
- 23 Which statements are correct about the compound below?



- 1 It reacts with H₂ in the presence of Pt catalyst to incorporate six hydrogen atoms into the compound.
- 2 It reacts with LiA/H₄ in dry ether to produce an organic compound containing one primary amine group.
- 3 It reacts with NaBH₄ to produce an organic compound containing one secondary alcohol group.
- A 1 and 2
- **B** 2 and 3
- C 1 only
- D 3 only

24 Two test tubes containing equal concentrations and volumes of ethanolic silver nitrate solution were placed in a heated water bath.

Equal amounts of two halogen-containing compounds, X and Y, were then added separately to these test tubes.

The mass of precipitate formed in each test tube was monitored and the results are shown graphically below.



Which compounds could be X and Y?



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

25 Buchwald–Hartwig amination is an organic reaction for the synthesis of carbon–nitrogen bonds from the reactions of amines with aryl halides.



Which is not a possible structure for Z?



26 Compound S contains only carbon, hydrogen and oxygen. It gives an orange precipitate with 2,4-dinitrophenylhydrazine. When compound S is heated with aluminium oxide, compound T is the only organic compound formed. 1 mol of compound T 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 **S**?

- 1 aldehyde
- 2 ketone
- 3 primary alcohol
- 4 tertiary alcohol
- A 1 and 3
- **B** 1 and 4
- **C** 2 and 3
- **D** 2 and 4

27 Enzyme Y will only hydrolyse a polypeptide chain at a peptide bond at the carboxylic acid end of lysine. Enzyme Z will only hydrolyse a polypeptide chain at a peptide bond at the carboxylic acid end of either glycine or alanine.

 glycine
 alanine
 lysine

 H_2N COOH
 H_2N COOH

 H_2N COOH
 H_2N H_2N

The structures of these amino acids are shown.

How many moles of dipeptides will be produced when 1 mol of the following cyclic polypeptide was hydrolysed by both enzymes **Y** and **Z**?



- **28** Compound **X** has the molecular formula $C_9H_{12}O_2$.
 - X gives a yellow precipitate with alkaline aqueous iodine.
 - **X** decolourises Br₂ in CCl₄.

Which compound could be the product formed when **X** is heated with acidified potassium dichromate(VI)?



29 An electrochemical cell was set up under standard conditions consisting of the following half-cells.

$$\begin{array}{ll} N_2(g) + 4H_2O(l) + 4e^- \rightleftharpoons N_2H_4(aq) + 4OH^-(aq) & E^{\ominus} = -1.16 \ V \\ N_2H_4(aq) + 2H_2O(l) + 2e^- \rightleftharpoons 2NH_3(aq) + 2OH^-(aq) & E^{\ominus} = +0.10 \ V \end{array}$$

Which statements are correct?

- 1 The decomposition of $N_2H_4(aq)$ to $NH_3(aq)$ and $N_2(g)$ is spontaneous under basic conditions.
- 2 Increasing the pH in the N₂/N₂H₄ half-cell will cause $E_{cell} > E_{cell}^{\ominus}$.
- 3 Adding water to the N₂H₄/NH₃ half-cell will cause $E_{cell} > E^{\ominus}_{cell}$.
- **A** 1, 2 and 3
- **B** 1 and 3 only
- **C** 2 and 3 only
- **D** 1 only

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

The following electrochemical cell was set up to investigate the ΔG^{\ominus} of neutralisation.



What is the ΔG^{\ominus} of neutralisation?

- A −160 kJ mol⁻¹
- **B** -80.1 kJ mol⁻¹
- **C** +80.1 kJ mol⁻¹
- **D** +160 kJ mol⁻¹