

RAFFLES INSTITUTION 2019 YEAR 6 PRELIMINARY EXAMINATION



CHEMISTRY

Paper 1 Multiple Choice



9729/01 30 September 2019 1 hour

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, highlighters, glue or correction fluid. Write your name, class and index number in the spaces provided on the Answer Sheet.

There are thirty questions in this section. 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.

1 Copper has two stable isotopes, ⁶³Cu and ⁶⁵Cu.

Which statement is correct?

- **A** ${}^{63}Cu^{2+}$ ion has fewer protons than ${}^{65}Cu^{+}$ ion.
- **B** The electronic configuration of ${}^{63}Cu^+$ is [Ar] $3d^9 4s^1$.
- C ⁶³Cu⁺ ion has the same number of neutrons as ⁶⁵Cu³⁺ ion.
- **D** 63 Cu⁺ ion has fewer unpaired electrons than 65 Cu³⁺ ion.
- 2 Information about some compounds are given below.

compound	chemical formula	boiling point / °C
hydrogen peroxide	H_2O_2	150
dihydrogen disulfide	H_2S_2	70.7
hydrazine	N_2H_4	114

Which statements about these compounds are correct?

- 1 All three molecules contain at least one σ bond formed by sp³-s orbital overlap.
- 2 The H–O–O bond angle in H_2O_2 is greater than the H–S–S bond angle in H_2S_2 .
- 3 H_2S_2 has the weakest instantaneous dipole-induced dipole interaction.
- 4 N_2H_4 has less extensive hydrogen bonding than H_2O_2 .

Α	1 and 2 only	В	2 and 3 only
С	1 and 4 only	D	1, 3 and 4 only

3 Which compound has the highest solubility in water?

- $A \qquad CH_3CH_2CH_2NH_2$
- B CH₃CH₂CO₂Na
- $C \qquad CH_3CH_2CH_2Cl$
- D $CH_3CH_2CH_2CH_3$
- 4 An air-filled plastic ball has a volume of 30.0 cm³.

At 22 °C and 100 kPa, a slightly dented plastic ball of volume 27.5 cm³ is filled with air. To restore its spherical shape, the air inside the dented ball is heated to 57 °C. The pressure of air inside the ball increases and creates a uniform outward force.

Assuming that the air inside the plastic ball behaves ideally, what is the pressure of air inside the plastic ball at 57 °C when its shape is restored?

A 92 kPa B 103 kPa C 112 kPa	a D 238 kPa
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5 0.010 mol of the chlorides of A*l*, Si and P were added separately to 1.0 dm³ of water.Which graph shows the correct trend of the pH of the resulting mixtures?



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

Which statements regarding the Group 17 elements and their hydrides are correct?

- 1 HI is more volatile than HBr because of the weaker bond strength between H and I atoms.
- 2 HF is thermally more stable than HI because of the stronger bond strength between H and F atoms.
- 3 Cl_2 is a stronger oxidising agent than Br_2 because of the stronger bond strength between Cl atoms.

Α	2 only	В	1 and 3 only
С	2 and 3 only	D	1, 2 and 3 only

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7 Complete combustion of ethyl mercaptan, CH₃CH₂SH, produces carbon dioxide, water and sulfur dioxide, as shown.

reaction 1 $2CH_3CH_2SH + 9O_2 \longrightarrow 4CO_2 + 6H_2O + 2SO_2$

In an experiment, it was found that complete combustion of 17.0 g of ethyl mercaptan raised the temperature of 1000 g of water in a calorimeter from 25 °C to 85 °C. This process is 60% efficient and the specific heat capacity of water is 4.18 J g^{-1} K⁻¹.

What is the enthalpy change of reaction 1?

Α	–550 kJ mol⁻¹	В	–1099 kJ mol ^{–1}
С	–1527 kJ mol ^{–1}	D	–3054 kJ mol ⁻¹

8 Under acidic conditions, iodine reacts readily with propanone to form 1-iodopropanone as shown below.

 $CH_{3}COCH_{3}(aq) + I_{2}(aq) \xrightarrow{H^{+}(aq)} CH_{3}COCH_{2}I(aq) + HI(aq)$

The rate of the reaction can be calculated from the following expression.

 $\label{eq:rate} \mbox{rate of reaction} \propto \frac{\mbox{volume of } I_2(aq) \mbox{ used}}{\mbox{time taken for the colour of iodine to disappear}}$

The time taken for the colour of iodine to disappear is tabulated below.

experiment	volume of 0.1 mol dm ⁻³ CH ₃ COCH ₃ used/cm ³	volume of 0.1 mol dm ⁻³ I_2 used/cm ³	volume of 0.1 mol dm ⁻³ H ⁺ used/cm ³	volume of water added/ cm ³	time taken for the colour of I ₂ to disappear/ min
1	40.0	20.0	40.0	0.0	1
2	40.0	20.0	20.0	20.0	2
3	20.0	20.0	40.0	20.0	2
4	40.0	10.0	40.0	10.0	0.5
5	40.0	10.0	10.0	40.0	х

Which statements are correct?

- 1 The units for the rate constant is mol⁻¹ dm³ min⁻¹.
- 2 The time taken for the colour of I_2 to disappear in experiment 5 is 2 min.
- 3 Using 0.2 mol dm⁻³ I₂ will not change the time taken for each experiment.
- A 1 and 2 only B 1 and 3 only
- C
 2 and 3 only
 D
 1, 2 and 3 only

9 Ozone naturally decomposes to oxygen according to the equation below.

$$2O_3(g) \rightarrow 3O_2(g)$$

Cl• radicals, formed from chlorofluorocarbon compounds (CFCs) in the upper atmosphere, speeds up the reaction through a chain reaction involving the following steps:

Step 1:
$$Cl \bullet + O_3 \square Cl O \bullet + O_2$$
 fast
Step 2: $Cl O \bullet + O_3 - \frac{k_2}{2} > Cl \bullet + 2O_2$ slow

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

Which statements are correct?

- 1 Cl• functions as a catalyst of the chain reaction.
- 2 ClO• functions as a catalyst of the chain reaction.
- 3 Step 2 has a lower activation energy than step 1.
- 4 Step 2 has a lower activation energy than the uncatalysed reaction.

Α	1 and 2 only	В	1 and 4 only
С	1, 2 and 4 only	D	2, 3 and 4 only

10 Which is the correct overall rate equation for the catalysed decomposition of ozone?

A rate =
$$k_2[Cl\bullet][O_3]$$

B rate = $k_2[ClO\bullet][O_3]$
C rate = $k_2K_1[Cl\bullet][O_3]^2$
D rate = $k_2K_1\frac{[Cl\bullet][O_3]^2}{[O_2]}$

11 Methanol can be synthesised from hydrogen and carbon monoxide using a suitable catalyst at 480 K and a pressure of 3×10^6 Pa.

$$2H_2(g) + CO(g) \square CH_3OH(g)$$
 $\Delta H = -90.6 \text{ kJ mol}^{-1}$

After the reaction mixture reached equilibrium under the above conditions, the temperature was increased to 550 K.

Which option correctly describes the changes which take place?

 $K_{\rm p}$ is the equilibrium constant, and $k_{\rm f}$ and $k_{\rm b}$ are the rate constants for the forward and backward reactions respectively.

	yield of CH ₃ OH	$K_{ m p}$	$k_{ m f}$	<i>k</i> b
Α	increase	increase	increase	decrease
В	decrease	increase	increase	increase
С	decrease	decrease	increase	increase
D	decrease	decrease	decrease	increase

12 NH_3 and BF_3 forms a solid adduct NH_3BF_3 via dative covalent bonding.

$$NH_3(g) + BF_3(g) \square NH_3BF_3(s)$$

 K_{p} is the equilibrium constant of the above reaction.

Which of the following expressions gives the concentration, in mol dm⁻³, of $NH_3(g)$ at 298 K?

$$\begin{array}{ccc} \textbf{A} & & \frac{1}{[BF_{3}]K_{P}} \\ \textbf{B} & & \frac{1}{P_{BF_{3}}K_{P}} \\ \textbf{C} & & \frac{1}{P_{BF_{3}}(8.31)(298)K_{P}} \\ \textbf{D} & & \frac{1}{P_{BF_{3}}(8.31)(1000)(298)K_{P}} \end{array}$$

13 Two aqueous solutions of HF and HC*l* were prepared at pH 3. It was found that the HF solution required 30 cm³ of a NaOH solution to neutralise, while the HC*l* solution required 20 cm³ of the same NaOH solution to neutralise.

Which of the following can be determined from the above information?

- **A** $F^{-}(aq)$ is more stable than $Cl^{-}(aq)$
- **B** HF is more polar than HC*l*
- **C** The pK_a of HF is greater than HCl
- **D** HF releases more H⁺ than HC*l*
- 14 Glutamic acid is a naturally occurring amino acid with the following formula.



FA1 is 0.1 mol dm⁻³ aqueous glutamic acid. **FA2** is 0.5 mol dm⁻³ aqueous sodium hydroxide.

Which mixture of FA1 and FA2 is best able to resist pH change?

	volume of FA1 / cm ³	volume of FA2 / cm ³
Α	50	10
В	50	15
С	50	20
D	50	30

15 The K_{sp} values of the following silver(I) salts are given.

silver(I) salt	K _{sp}
Ag ₃ PO ₄	8.89 x 10 ⁻¹⁷
Ag ₂ CO ₃	8.46 x 10 ⁻¹²
AgCl	1.77 x 10 ⁻¹⁰

An aqueous solution contains 1 mol dm⁻³ each of Na₃PO₄, Na₂CO₃, and NaC*l*. Which silver(I) salts are obtained as the first and second precipitates on careful addition of aqueous AgNO₃?

	first precipitate	second precipitate
Α	AgC <i>l</i>	Ag ₃ PO ₄
В	AgC <i>l</i>	Ag_2CO_3
С	Ag₃PO₄	AgC <i>l</i>
D	Ag ₃ PO ₄	Ag ₂ CO ₃

16 GABA, a naturally occurring neurotransmitter, was converted to compound X through the following series of reactions.



Which type of reaction did not take place?

Α	substitution	В	addition
С	condensation	D	elimination

17 1-(Chloromethyl)-4-nitrobenzene can be synthesised from benzene via a 3-step synthetic method.



1-(chloromethyl)-4-nitrobenzene

Which of the following sequence of reactions when carried out, gives the best yield of 1-(chloromethyl)-4-nitrobenzene?

	step 1	step 2	step 3
Α	alkylation	free radical substitution	nitration
В	nitration	alkylation	free radical substitution
С	alkylation	nitration	free radical substitution
D	free radical substitution	nitration	alkylation

18 What is the major product obtained when the following compound is treated with hot alcoholic potassium hydroxide?



19 Which of the following reactions can be carried out with the same set of reagents and conditions?



20 Chloramphenicol is an antibiotic used to treat conjunctivitis.



chloramphenicol

Which statement about chloramphenicol is correct?

- Α It exhibits enantiomerism.
- В It contains 8 sp² carbon atoms.
- С It decolourises cold, acidified KMnO₄(aq) together with the formation of $CO_2(g)$.
- D It produces ethanoic acid as one of the products when heated with an acidified solution of KMnO₄(aq).
- 21 Which of the following cannot be used to distinguish between the following compounds?



- Α hot acidified potassium dichromate(VI)
- В sodium carbonate
- С neutral iron(III) chloride
- D Tollens' reagent
- 22 After 10 minutes of heating C₈H₉Br with ethanolic AgNO₃, a precipitate was observed.

Compound **D**, C_8H_9X (where X is a halogen), undergoes the same treatment and a precipitate was observed after 15 minutes.

Which statements about compound **D** are correct?

- 1 It produces a white precipitate when heated with ethanolic AgNO₃.
- 2 There are 4 possible structures (ignoring stereoisomers) for compound **D**.
- It is a halogenoarene. 3

Α	1, 2 and 3	В	1 and 2
С	2 and 3	D	1 only

2 and 3 D 1 only **23** 1-Chlorobut-2-ene reacts with alcoholic KCN via a substitution reaction to give the following product mixture.

$$CH_{3}CH=CH-CH_{2}-C/ \xrightarrow{alcoholic KCN} + CH_{3}CH=CH-CH_{2}-CN$$

This reaction involves the formation of a carbocation $CH_3CH=CH-CH_2$ in the slow step of the mechanism. This carbocation can undergo rearrangement to form a more stable carbocation **C**.

The nucleophile then attacks both carbocations in the fast step, forming the product mixture.

Which statement about the above reaction is correct?

- A The reaction occurs with inversion of configuration with respect to the C atom at which substitution occurs.
- **B** Homolytic fission of C—C*l* bond occurs in the slow step.
- **C** Carbocation **C** is $CH_3CH-CH=CH_2$
- **D** The product mixture is optically inactive.
- 24 Compound **E** has the following structure.



Which statement about compound **E** is correct?

- **A** The p*K*_b of the three labelled nitrogen atoms in increasing order is $N_{\beta} < N_{\alpha} < N_{\gamma}$.
- **B** 1 mole of compound **E** reacts with 3 moles of ethanoic acid at room temperature.
- **C** 1 mole of compound **E** reacts with 1 mole of CH_3COCl at room temperature.
- **D** Compound **E** forms an orange precipitate with 2,4–dinitrophenylhydrazine.



25 Consider the structure of the following cyclic polypeptide.

Which of the following are products of hydrolysis with hot concentrated alkali?



26 The following diagram shows an alkaline battery, which is commonly used to power simple electronic devices.



When the battery is in use, the following reaction takes place.

 $Zn + 2MnO_2 + H_2O \rightarrow Mn_2O_3 + Zn(OH)_2$

Which of the following statements are correct?

- 1 The graphite rod is the positive electrode.
- 2 $E^{\ominus}(\operatorname{Zn}(\operatorname{OH})_2/\operatorname{Zn}) < E^{\ominus}(\operatorname{MnO}_2/\operatorname{Mn}_2\operatorname{O}_3).$
- 3 Increasing the volume of KOH paste leads to a higher E_{cell} value.

Α	1 and 2	С	2 and 3
В	1 and 3	D	1, 2 and 3

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

Approximately 2 g of a pure organic acid with the structural formula $CH_3(CH_2)_nCOOH$ (n = 1, 2, 3 or 4) was added into a beaker of water. This aqueous solution was used in the cathode of an electrolytic cell.

After passing a current of 6.0 A through the aqueous solution for 6 minutes, the organic acid was found to be completely neutralised.

What is the identity of the organic acid?

- A CH₃CH₂COOH
- B CH₃(CH₂)₂COOH
- C CH₃(CH₂)₃COOH
- D CH₃(CH₂)₄COOH

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

The diagram below shows a voltaic cell.



Which of the following will decrease the cell potential?

- **A** Using a smaller piece of Zn electrode for the (Zn^{2+}/Zn) half-cell.
- **B** Adding excess concentrated NH_3 into the (Zn^{2+}/Zn) half-cell.
- **C** Adding a few drops of aqueous $Ba(NO_3)_2$ into the (SO_4^{2-}/SO_2) half-cell.
- **D** Decreasing the pressure of SO_2 for the (SO_4^{2-}/SO_2) half-cell.

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

A student mixed up three bottles of solutions (**X**, **Y** and **Z**) which contained Ag^+ , Zn^{2+} and Mg^{2+} separately. To identify the solutions, he conducted two electrolytic experiments, one with the original solutions and one with diluted solutions.

The following table shows his observations at the negative electrode.

	original solutions	diluted solutions
Х	increase in mass	increase in mass
Y	increase in mass	effervescence
Z	effervescence	effervescence

Based on the information above, which is correct?

	Х	Y	Z
Α	Ag⁺	Zn ²⁺	Mg ²⁺
В	Mg ²⁺	Ag⁺	Zn ²⁺
С	Mg ²⁺	Zn ²⁺	Ag⁺
D	Zn ²⁺	Mg ²⁺	Ag⁺

30 The following shows nickel(II) ions in two different reactions.

reaction 1 $[Ni(H_2O)_6]^{2+} + 6NH_3 \rightleftharpoons [Ni(NH_3)_6]^{2+} + 6H_2O$ *reaction 2* $[Ni(H_2O)_6]^{2+} + 3H_2NCH_2CH_2NH_2 \rightleftharpoons [Ni(H_2NCH_2CH_2NH_2)_3]^{2+} + 6H_2O$

Which of the following statements is not correct?

- **A** The entropy change, ΔS , for reaction 1 is less positive than that for reaction 2.
- **B** The stability constant of $[Ni(NH_3)_6]^{2+}$ is larger than that of $[Ni(H_2NCH_2CH_2NH_2)_3]^{2+}$.
- **C** Both reactions are ligand exchange reactions.
- **D** The geometry about Ni in $[Ni(H_2NCH_2CH_2NH_2)_3]^{2+}$ is the same as that in $[Ni(NH_3)_6]^{2+}$.