Candidate Name:



2020 Preliminary Examination

Pre-University 3

9729/01
22 Sep 2020
1h

# READ THESE INSTRUCTIONS FIRST

# Do not turn over this question paper 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 admission number in the spaces provided at the top of this page and on the Multiple Choice Answer Sheet provided.

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 Multiple Choice Answer Sheet provided.

## 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 question paper.

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

FOR EXAMINER'S USE					
TOTAL (30 marks)					





For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 Which statement about a 36.0 g sample of <sup>18</sup>O<sub>2</sub> is correct?
  - **A** There are  $6.02 \times 10^{23}$  <sup>18</sup>O atoms in the sample.
  - **B** The number of atoms is the same as the number of atoms in a 32.0 g sample of  ${}^{16}O_2$ .
  - **C** The number of moles in the sample is the same as the number of moles in a 40.0 g sample of  $H_2^{18}O$ .
  - **D** The number of molecules is the same as the number of atoms in a 20.0 g sample of  $H_2^{18}O$ .
- 2 In gold mining, potassium cyanide is used to dissolve gold in order for easier extraction. The equation, commonly known as the Elsner equation, is given below.

4 Au + 8 KCN +  $O_2$  + 2 $H_2O \rightarrow$  4 K[Au(CN)<sub>2</sub>] + 4 KOH

What is the minimum volume of oxygen required to dissolve 1 kg of gold, assuming room temperature and pressure?

- **A** 28.8 dm<sup>3</sup>
- **B** 30.5 dm<sup>3</sup>
- **C** 461 dm<sup>3</sup>
- **D** 487 dm<sup>3</sup>
- 3 Which of the following experiences the greatest deflection in the same electric field?

**A**  ${}^{3}\text{H}^{+}$  **B**  ${}^{9}\text{F}^{-}$  **C**  ${}^{12}\text{Mg}^{2+}$  **D**  ${}^{32}\text{S}^{2-}$ 

- 4 Which of the following pairs have the same molecular shape?
  - **A** BC $l_3$  and IC $l_3$
  - B HCN and H<sub>2</sub>O
  - C CF<sub>4</sub> and SF<sub>4</sub>
  - $\textbf{D} \qquad SCl_2 \text{ and } H_2S$

- **5** Which of the following pairs contains a compound held together by permanent dipole-permanent dipole interactions and a compound containing ionic bonds?
  - A  $ClO_2$ ,  $AlCl_3$
  - **B** HCl, AlCl<sub>3</sub>
  - **C** NH<sub>4</sub>Cl, NaCl
  - D HCl, NaCl
- 6 Which of the following molecules will not form hydrogen bonds with another of its own molecule?
  - A CH<sub>3</sub>OCH<sub>3</sub>
  - B CH<sub>3</sub>COOH
  - **C** (CH<sub>3</sub>)<sub>3</sub>CNH<sub>2</sub>
  - D (CH<sub>3</sub>)<sub>2</sub>CHOH
- 7 To determine the enthalpy change of solution of NH<sub>4</sub>Cl(s), the enthalpy changes of the following reactions are determined.

$$\begin{split} \mathsf{NH_4^+}(g) & \longrightarrow \mathsf{NH_4^+}(aq) \\ \mathsf{NH_4C}{\it l}(s) & \longrightarrow \mathsf{NH_4^+}(g) + C{\it l^-}(g) \end{split}$$

Which of the following enthalpy changes is needed in order to determine the enthalpy change of solution of  $NH_4Cl(s)$ ?

- A The first electron affinity of chlorine atom
- **B** The enthalpy change of atomisation of gaseous chlorine molecule
- C The enthalpy change of hydration of gaseous chloride ion
- **D** The enthalpy change of formation of solid ammonium chloride

**8** Hydrazine, N<sub>2</sub>H<sub>4</sub>, is used as a propellant in spacecraft propulsion. Hydrazine can be manufactured from ammonia using the following reaction.

$$2NH_3(g) + H_2O_2(l) \rightarrow N_2H_4(l) + 2H_2O(l)$$

Using the following information, what is the standard enthalpy change for this reaction in kJ mol<sup>-1</sup>?

Compound	ΔH <sub>f</sub> <sup>0</sup> / kJ mol <sup>-1</sup>
NH₃(g)	-80.8
$H_2O_2(l)$	-187.3
$N_2H_4(l)$	+97.4
$H_2O(l)$	-285.8

**A** -79.7 **B** -125.3 **C** +79.7 **D** +125.3

9 Under which set of conditions will any reaction be spontaneous at all temperatures?

	ΔΗ	ΔS
Α	positive	negative
В	positive	positive
С	negative	positive
D	negative	negative

10 An ideal gas is described as a theoretical gas that obeys the ideal gas equation.

Which of the following correctly explains why a real gas deviates from ideal gas behaviour?

- 1 Real gas molecules travel in a non-random manner.
- 2 Real gas molecules have a definite volume.
- 3 Real gas molecules have forces of attraction between them.
- **A** 1, 2 and 3
- **B** 1 only
- C 1 and 3 only
- D 2 and 3 only

- A BF<sub>3</sub>
- B OH-
- **C** H<sub>2</sub>O
- D NH<sub>3</sub>

12 In which reaction does ammonia function as a base?

- 1  $2NH_3(l) + 2Na(s) \rightarrow 2NaNH_2(s) + H_2(g)$
- 2  $NH_3(g) + H_2O(l) \rightarrow NH_4^+(aq) + OH^-(aq)$
- 3  $NH_3(g) + H_2S(g) \rightarrow NH_4^+(g) + HS^-(g)$
- **A** 1, 2 and 3
- B 1 and 2 only
- C 2 and 3 only
- D 2 only
- 13 The reaction  $X(g) + 2Y(g) \rightarrow Z(g)$  is found to have the rate equation rate = k[X] and a rate constant of 1.155 × 10<sup>-3</sup> s<sup>-1</sup>. If the initial concentration of X is 2.50 × 10<sup>-3</sup> mol dm<sup>-3</sup>, what is the concentration of X in mol dm<sup>-3</sup> after 30 minutes?
  - **A** 3.13 × 10<sup>-4</sup>
  - **B** 6.25 × 10<sup>-4</sup>
  - **C** 1.25 × 10<sup>-3</sup>
  - **D** 2.00 × 10<sup>-3</sup>

**14** The mechanism for the reaction between nitrogen monoxide and oxygen is believed to be as follows.

$$\begin{split} \mathsf{NO} + \mathsf{NO} &\rightleftharpoons \mathsf{N}_2\mathsf{O}_2 \quad \text{(fast)} \\ \mathsf{O}_2 + \mathsf{N}_2\mathsf{O}_2 &\longrightarrow \mathsf{NO}_2 + \mathsf{NO}_2 \quad \text{(slow)} \end{split}$$

Which of the following rate equation is consistent with the mechanism?

- **A** rate =  $k[O_2][N_2O_2]$
- **B** rate =  $k[NO]^2$
- c rate =  $k[NO]^2[O_2]$
- **D** rate =  $k[NO][O_2]$
- **15** The following reaction is non-spontaneous under standard conditions.

$$2NO_3(aq) + 8H(aq) + 6Cl(aq) \rightleftharpoons 2NO(g) + 4H_2O(l) + 3Cl_2(g)$$

Which of the following conditions can help to aid the reaction to happen?

- 1 Adding H<sub>2</sub>SO<sub>4</sub>
- 2 Adding NaNO<sub>3</sub>
- 3 Adding NaOH
- A 1, 2 and 3
- **B** 1 and 2 only
- C 2 and 3 only
- D 1 only
- 16 Nitrosyl bromide gas is placed in a vessel of constant volume and an equilibrium is set up.

$$2NOBr (g) \rightleftharpoons 2NO(g) + Br_2(g)$$

The total equilibrium pressure is larger than the initial pressure of nitrosyl bromide by 25%. What is the mole fraction, *x*, of bromine in this equilibrium mixture?

Α	0.200	В	0.250	С	0.333	D	0.500
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17 Methanol is produced industrially through the reaction between carbon dioxide and hydrogen, over a copper/zinc-oxide mixture as a catalyst. The reaction is carried out at 50-100 atm and 250 °C.

 $CO_2(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$   $\Delta H < 0$ 

Which of the following explains the choice of these conditions?

- A At lower pressures, the catalyst works more efficiently.
- **B** At lower pressures, the rate of formation increases.
- **C** At lower temperatures, the rate of formation of methanol increases.
- **D** At lower temperatures, the yield of methanol increases.
- The pK<sub>b</sub> value for aqueous ammonia at 25 °C is 4.80.
  What is the pH of a solution containing 50 cm<sup>3</sup> of 0.80 mol dm<sup>-3</sup> of aqueous ammonia and 50 cm<sup>3</sup> of 0.50 mol dm<sup>-3</sup> of nitric acid?
  - **A** 3.31
  - **B** 5.02
  - **C** 8.98
  - **D** 10.7
- **19** Phosphoric acid is a weak acid that is sometimes found in soft drinks. It dissociates in water in the manner below:

$$H_{3}PO_{4}(aq) \rightleftharpoons H_{2}PO_{4}(aq) + H^{+}(aq) \qquad K_{a} = 7.1 \times 10^{-3}$$
$$H_{2}PO_{4}(aq) \rightleftharpoons HPO_{4}(aq) + H^{+}(aq) \qquad K_{a} = 6.3 \times 10^{-8}$$

Which of the following describes the concentrations of the species present in equilibrium?

- **A**  $[H_3PO_4] > [H_2PO_4^-] > [HPO_4^{2-}]$
- **B**  $[HPO_4^2] > [H_2PO_4] > [H_3PO_4]$
- **C**  $[H_3PO_4] > [HPO_4^2] = [H_2PO_4]$
- **D**  $[H_3PO_4] = [H_2PO_4^-] > [HPO_4^2^-]$

**20** Two solutions of 20 cm<sup>3</sup> of CH<sub>3</sub>COOH and HC*l* with the same concentration were respectively titrated against NaOH solution.

Which of the following will be the same for both reactions?

- 1 Initial pH
- 2 Volume of NaOH required to reach equivalence point
- 3 pH at equivalence point
- A 1 only
- B 2 only
- **C** 1, 2 and 3
- **D** 1 and 2 only
- 21 Magnesium phosphate,  $Mg_3(PO_4)_2$  is a sparingly soluble salt. If the solubility product of  $Mg_3(PO_4)_2$  is given as **M**, what is the concentration of  $PO_4^{3-}$  at equilibrium?



22 The following graph shows the first ionisation energies of eight consecutive elements **J** to **R**, which have atomic numbers between 3 to 20 in the Periodic Table.



Which one of the following statements about the elements is true?

- A Atomic radius of J is smaller than K.
- **B M** exists as discrete molecules.
- **C** The chloride of **Q** reacts with water to form an acidic solution.
- D Oxides of R can react with acids.

#### **23** Use of the Data Booklet is relevant to this question.

Electroplating is a common process to prevent corrosion. Numerous objects can be electroplated, including keys. A metal key is dipped into a CuSO<sub>4</sub> solution where it acts an electroplating setup.

Which of the following statements is correct?

- 1 The key acts as a cathode in the electrolytic cell.
- 2 0.0987 g of copper will be deposited on the key in 30s if a 10A current is used.
- 3 The electrolyte will turn universal indicator green at the end of the electroplating process.
- A 1 only
- **B** 3 only
- C 1 and 2 only
- D 2 and 3 only

24 Propanal can react with ammonia as shown.

 $CH_{3}CH_{2}CHO + NH_{3} \rightarrow CH_{3}CH_{2}CH(OH)NH_{2}$ 

Which type of reaction is this?

- A Nucleophilic addition
- **B** Elimination
- **C** Electrophilic substitution
- D Addition-elimination
- 25 Which of the carbon atoms in the molecule below is sp<sup>2</sup> hybridised?



- A W and Z only
- **B** X and Y only
- C X only
- D Z only

26 Which of the statements are true about 2-chloroethanoic acid and 2-bromoethanoic acid?

- 1 2-chloroethanoic acid can precipitate faster than 2-bromoethanoic acid when both are reacted with ethanolic AgNO<sub>3</sub>.
- 2 2–chloroethanoic acid is a stronger acid than 2–bromoethanoic acid.
- 3 2-chloroethanoic acid contains a stronger electron-withdrawing group than 2bromoethanoic acid.
- A 1, 2 and 3
- B 2 only
- C 1 and 3 only
- D 2 and 3 only

- 27 Which of the following pairs of reagents will react together to give a water-soluble organic product?
  - 1  $CH_3CH_2COOH$  and  $LiAlH_4$
  - $2 \qquad \mathsf{CH}_3\mathsf{CH}_2\mathsf{COOH} \text{ and } \mathsf{CH}_3\mathsf{CH}_2\mathsf{NH}_2$
  - 3  $CH_3CH_2CH_2Cl$  and NaOH
  - **A** 1, 2 and 3
  - B 1 and 3 only
  - C 2 and 3 only
  - D 1 and 2 only
- 28 Which of the following is **not** a possible product when 2-methylpropene is reacted with a mixture containing Br<sub>2</sub> and IC/?



**29** Compound **X** reacts with 1 mol of sodium hydroxide at room temperature and 2 mol of sodium hydroxide when heated.

Which of the following could be a possible structure of compound X?



**30** Glutamic acid is one of the neutrotransmitters present in the nervous system.



Which of the following statements is false about glutamic acid?

- A It exists as a crystalline solid at room temperature.
- **B** It exists as a zwitterion at pH 7.
- **C** The two carboxylic groups have different  $pK_{a}$ .
- **D** There is only 1 chiral centre in glutamic acid

#### END OF PAPER 1

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