# ANGLO-CHINESE JUNIOR COLLEGE DEPARTMENT OF CHEMISTRY Preliminary Examination

# CHEMISTRY Higher 2

9729/01

Paper 1 Multiple Choice

24 August 2017 1 hour

Additional Materials: Optical Answer Sheet Data Booklet

# READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluids. Write your name, index number and tutorial class on the Optical Answer Sheet in the spaces provided unless this has been done for you.

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 Optical Answer Sheet.

#### Read the instructions on the Optical 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.

This document consists of **14** printed pages, including this cover page.

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ANGLO-CHINESE JUNIOR COLLEGE Department of Chemistry

[Turn over

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

1 Carbon disulfide is a colourless volatile liquid with the formula CS<sub>2</sub>. The compound is used frequently as a building block in organic chemistry as well as an industrial solvent.

It reacts with nitrogen monoxide, NO, to form a yellow solid and two gases. These two gases are formed in equal amounts.

What are these two gases?

**A** CO<sub>2</sub>, NO<sub>2</sub> **B** CO<sub>2</sub>, N<sub>2</sub> **C** CO, N<sub>2</sub> **D** CO<sub>2</sub>, N<sub>2</sub>O

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

Which of the following ions will be deflected the **most** in an electric field?

**A** S<sup>2-</sup> **B** Br<sup>-</sup> **C** F<sup>-</sup> **D** O<sup>2-</sup>

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

Nuclear magnetic resonance (NMR) spectroscopy is an analytical technique that uses the magnetic properties of certain atomic nuclei in order to elucidate the structure of an organic molecule.

Atomic nuclei with an even number of protons and an odd number of neutrons (or vice versa) are most suitable for NMR spectroscopy.

Which of the following nuclei is **least** suitable for NMR spectroscopy?

**A** <sup>28</sup>Si **B** <sup>31</sup>P **C** <sup>103</sup>Rh **D** <sup>19</sup>F

**4** A 25.00 cm<sup>3</sup> sample of a solution of 0.150 mol dm<sup>-3</sup> MoO<sub>x</sub><sup>2-</sup> was passed through a Jones reductor (a column of zinc powder). It was reduced to Mo<sup>3+</sup>. The filtrate required 22.50 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> acidified KMnO<sub>4</sub> (aq) to obtain back the original amount of MoO<sub>x</sub><sup>2-</sup>.

What is the value of *x*?

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

5 Neoxanthin is a major xanthophyll found in green leafy vegetables such as spinach.



Which of the following  $\sigma$  bonds are present in neoxanthin?

- 1 A  $\sigma$  bond formed by sp<sup>2</sup>–sp<sup>3</sup> overlap.
- **2** A  $\sigma$  bond formed by s–p overlap.
- **3** A  $\sigma$  bond formed by sp–sp<sup>2</sup> overlap.
- A 1 and 2 only
- **B** 1 and 3 only
- C 2 and 3 only
- **D** 1, 2 and 3
- 6 The enthalpy changes for the following reactions were measured experimentally:

$CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$	$\Delta H = -2202 \text{ kJ mol}^{-1}$
$H_2(g) + \frac{1}{2} O_2(g) \to H_2O(l)$	$\Delta H = -286 \text{ kJ mol}^{-1}$
$CH_3$ – $C≡C$ – $H(g) + 2H_2(g) \rightarrow CH_3CH_2CH_3(g)$	$\Delta H = -310 \text{ kJ mol}^{-1}$

What is the enthalpy change of combustion of propyne,  $CH_3-C\equiv C-H$ , in terms of kJ mol<sup>-1</sup>?

**A** -2226 **B** -1940 **C** -1606 **D** -1320

**7** 35 cm<sup>3</sup> of 0.001 mol dm<sup>-3</sup> nitric acid solution was added to 35 cm<sup>3</sup> of sulfuric acid solution of the same concentration. What is the resulting pH of the combined solution?

**A** 1.5 **B** 2.5 **C** 2.8 **D** 3.0

- 8 In which of the following pairs is the bond angle in the first species smaller than that in the second species?
  - 1  $PBr_3$ ,  $PBr_4^+$
  - 2 H<sub>2</sub>Se, H<sub>2</sub>O
  - **3** SF<sub>2</sub>, SC*l*<sub>2</sub>
  - A 1 and 2 only
  - B 1 and 3 only
  - C 2 and 3 only
  - **D** 1, 2 and 3
- 9 X and Y are both ideal gases. X has the smaller molecular mass.

Which of the following diagrams correctly describe the behaviour of equal masses of these gases? All temperatures are measured in °C.



5

# 10 X exists in equilibrium with Y and Z.

$$2\mathbf{X}(\mathbf{g}) \rightleftharpoons \mathbf{Y}(\mathbf{g}) + \mathbf{Z}(\mathbf{g})$$

The concentrations of **X**, **Y** and **Z** varies across time as shown below. Note that the dotted line refers to both concentrations of **Y** and **Z**.



Which of the following statements is false?

- A The equilibrium constant is dimensionless.
- **B** X(g) was taken out of the system at 20 s.
- **C** Given that the temperature was decreased at 35 s, it can be concluded that the forward reaction is endothermic.
- **D** Temperature has no effect on the spontaneity of this reaction.
- **11** The stepwise dissociation equations of phosphoric acid and the corresponding equilibrium constants are shown below.

$H_3PO_4 \rightleftharpoons H_2PO_4^- + H^+$	$K_a = 7.50 \times 10^{-3} \text{ mol dm}^{-3}$
$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$	$K_a = 6.20 \times 10^{-8} \text{ mol dm}^{-3}$
$HPO_4^{2-} \rightleftharpoons PO_4^{3-} + H^+$	$K_a = 2.20 \times 10^{-13} \text{ mol dm}^{-3}$

A phosphate buffer with pH 7 needs to be prepared.

Which is the best way to prepare such a solution?

- A Dissolving Na<sub>3</sub>PO<sub>4</sub> alone in water.
- **B** Dissolving  $H_3PO_4$  and  $NaH_2PO_4$  in water.
- **C** Dissolving Na<sub>2</sub>HPO<sub>4</sub> and Na<sub>3</sub>PO<sub>4</sub> in water.
- **D** Dissolving Na<sub>2</sub>HPO<sub>4</sub> and NaH<sub>2</sub>PO<sub>4</sub> in water.

- 6
- 12 An equilibrium can be represented by the equation below.

$$W$$
 (aq) +  $X$  (aq)  $\Rightarrow$   $Y$  (aq) +  $Z$  (aq)

In 0.50 dm<sup>3</sup> of a certain mixture, the concentrations of these substances at equilibrium were as shown:

Species	W	Х	Y	Z
Concentration / mol dm <sup>-3</sup>	1.00	2.00	2.00	1.00

A certain amount of **Y** was added to this equilibrium mixture.

What is the number of moles of **Y** added such that the new equilibrium [**W**] is 1.20 mol dm<sup>-3</sup>?

Assume that the temperature remained constant throughout.



**13** A sample of washing powder which contains a mixture of Na<sub>2</sub>CO<sub>3</sub> and NaHCO<sub>3</sub> was titrated with aqueous hydrochloric acid and the following titration curve was obtained.



What is the mole ratio of HCO<sub>3</sub><sup>-</sup> to CO<sub>3</sub><sup>2-</sup> in the washing powder?



**14** The table below contains the standard reduction potential values for some cobalt and mercury species.

half-equation	E% V	
$\mathrm{Co}^{3+}$ (aq) + e $\rightleftharpoons$ $\mathrm{Co}^{2+}$ (aq)	+1.82	
$Co^{2+}(aq) + 2e \rightleftharpoons Co(s)$	-0.28	
$Hg^{2+}(aq) + e \rightleftharpoons Hg^{+}(aq)$	+0.91	
$Hg^{+}(aq) + e \rightleftharpoons Hg(l)$	+0.80	

Which one of the following predictions is correct?

- A Both Co<sup>2+</sup> and Hg<sup>+</sup> will disproportionate.
- **B** Neither Co<sup>2+</sup> nor Hg<sup>+</sup> will disproportionate.
- **C** Only Co<sup>2+</sup> will disproportionate.
- **D** Only Hg<sup>+</sup> will disproportionate.
- **15** Use of the Data Booklet is relevant to this question.

The reaction between iodide and peroxydisulfate  $(S_2O_8^{2-})$  is slow due to its high activation energy.

Which of the following cannot function as a catalyst for the above mentioned reaction?

**A** V<sup>2+</sup> **B** Mn<sup>2+</sup> **C** Mn<sup>3+</sup> **D** Co<sup>3+</sup>

**16** The decomposition of hydrogen peroxide is a first order reaction.

It takes 20 minutes for a 0.140 mol dm<sup>-3</sup> solution of hydrogen peroxide to halve its concentration.

How much time (in minutes) does it take for a 0.280 mol dm<sup>-3</sup> solution of hydrogen peroxide to halve its concentration?

**A** 80 **B** 40 **C** 20 **D** 10

**17** The reaction mechanism between O<sub>2</sub> and HBr is as proposed:

HBr +  $O_2 \rightarrow HO_2Br$  (slow)

 $HO_2Br + HBr \rightarrow 2HOBr$ 

 $HOBr + HBr \rightarrow Br_2 + H_2O$ 

Which of the following statements is true?

- A The bromine in HO<sub>2</sub>Br is oxidised in the second step.
- **B** The overall equation is  $O_2 + 4HBr \rightarrow 2Br_2 + 2H_2O$ .
- **C** The half-life of this reaction is constant.
- **D** HO<sub>2</sub>Br is the only intermediate.
- **18** The numerical values of the solubility products at 25 °C for  $PbCl_2$  and  $PbI_2$  are  $1.70 \times 10^{-5}$  and  $9.80 \times 10^{-9}$  respectively.

What is the value of the equilibrium constant for the reaction below?

 $PbI_2(s) + 2Cl^-(aq) \rightleftharpoons PbCl_2(s) + 2I^-(aq)$ 

- **A** 3.01 x 10<sup>6</sup>
- **B** 1.73 x 10<sup>3</sup>
- **C** 5.76 x 10<sup>-4</sup>
- **D** 3.32 x 10<sup>-7</sup>
- **19** Mohr's salt is named after the German chemist Karl Friedrich Mohr, who made many important advances in the methodology of titration in the nineteenth century.

It is a double salt because it contains two cations and an anion.

Heating solid Mohr's salt with sodium hydroxide liberated a colourless gas. A green precipitate is also formed. It was insoluble in excess sodium hydroxide. On standing in air the solid turned brown.

What is the formula of Mohr's salt?

- **A** AgCr(CO<sub>3</sub>)<sub>2</sub>
- B Ag<sub>2</sub>Fe(CO<sub>3</sub>)<sub>2</sub>
- **C** Fe(NH<sub>4</sub>)(SO<sub>4</sub>)<sub>2</sub>
- **D**  $Fe(NH_4)_2(SO_4)_2$

20 Photographic film contains silver halides, which absorb light to form silver metal and halogens are formed. Different silver halides have different sensitivity to light and will undergo this process to a different extent.

During the development of the film, a solution of aqueous ammonia or sodium thiosulfate is used to dissolve the unreacted silver halides. However, sodium thiosulfate is preferred, as some silver halides are not soluble in aqueous ammonia.

Which statements concerning the above processes are correct?

- 1 Metallic silver forms a very stable complex with thiosulfate, hence silver halides are soluble.
- 2 The decomposition of the silver halide to metallic silver and the respective halogen is easier for AgBr than for AgC*l* because bromide is more reducing than chloride.
- **3** AgBr is less soluble than AgC*l* in aqueous ammonia, as solubility product of AgC*l* is of a higher value.
- A 1 and 2 only
- **B** 1 and 3 only
- C 2 and 3 only
- **D** 1, 2 and 3
- 21 Use of the Data Booklet is relevant to this question.



Which of the following statements about the above complex is false?

- A There are no 4s electrons in manganese in this complex.
- **B** This complex contains five ligands.
- **C** The coordination number of this complex is 5.
- **D** The oxidation number of manganese in this complex is +2.

22 Cobalt forms many coloured complexes with ligands such as  $H_2O$  and  $SCN^-$ .

A 100 cm<sup>3</sup> solution of  $Co^{2+}(aq)$  turns from pink to bright blue when 10 cm<sup>3</sup> of NaSCN(aq) is added to the solution.

 $[Co(H_2O)_6]^{2+}(aq) + 4SCN^{-}(aq) = [Co(SCN)_4]^{2-}(aq) + 6H_2O(l)$ pale pink blue

At equilibrium,  $[Co(H_2O)_6]^{2+}$  and  $[Co(SCN)_4]^{2-}$  are found to be present in a mole ratio of 1:10.

Given that  $\lg K_c$  for the equilibrium is 3.00, which of the following statements is **false**?

- **A** At equilibrium,  $[SCN^{-}] = 3.16 \times 10^{-1} \text{ mol dm}^{-3}$ .
- **B**  $[Co(SCN)_4]^{2-}$  is more stable than  $[Co(H_2O)_6]^{2+}$ .
- **C** The units of  $K_c$  is mol<sup>-4</sup> dm<sup>12</sup>.
- **D** Dilution of the reaction mixture decreases the ratio of  $[Co(H_2O)_6]^{2+}$  to  $[Co(SCN)_4]^{2-}$  at equilibrium.
- **23** Carbon disulfide, CS<sub>2</sub>, can be electrolysed into carbon subsulfide, C<sub>3</sub>S<sub>2</sub>, an unusual compound.

The boiling points of these two compounds are 46.2 °C and 90.0 °C respectively.

Which of the following statements are false?

- 1 Bromine is acting as a reducing agent in **II**.
- 2 C<sub>3</sub>S<sub>2</sub> has the higher boiling point because there are more covalent bonds to be broken than in CS<sub>2</sub>.
- 3 The carbon atoms in  $C_3S_2$  do not share a common oxidation state.
- A 2 and 3 only
- B 1 and 3 only
- C 1 and 2 only
- **D** 1, 2 and 3

24 L-lyxose and D-xylose are monosaccharides.



Which of the following statements are true?

- 1 They have the same melting point.
- 2 The same volume of hydrogen gas is produced when excess sodium is added to equal amounts of each of them under the same conditions.
- **3** Both compounds undergo intramolecular nucleophilic substitution to form cyclic esters.
- A 1 and 2 only
- **B** 1 and 3 only
- C 2 and 3 only
- D 2 only
- 25 Cyproterone acetate (abbreviated as CPA) is a drug that is used in the treatment of androgen-related conditions like acne and prostate cancer.



Which of the following statements about CPA are correct?

- **1** One mole of CPA undergoes condensation with three moles of 2,4-dinitrophenylhydrazine.
- 2 Two moles of yellow precipitate is formed when one mole of CPA is warmed with alkaline iodine solution.
- **3** CPA does not cause a colour change in hot acidified potassium dichromate(VI).
- A 1 and 3 only
- B 1 and 2 only
- C 2 and 3 only
- D 3 only

26 Xantocillin was first isolated from *Penicillium notatum* in the 1950s. It is used as an antibiotic.



xantocillin

Which of the following statements about xantocillin is false?

- A It is a nitrile.
- **B** It exists as three cis-trans isomers.
- **C** There are four sp hybridised atoms.
- **D** It gives a violet colouration on adding neutral iron(III) chloride.
- 27 Ketenes are important reagents in organic synthesis. They can be formed from carboxylic acids via the synthetic route below.



Which of the following statements about the above reaction are correct?

- 1 The ketene will always be non-chiral, no matter which **Z** is used as the starting reactant.
- 2 Hydrochloric acid can be used as the reagent in step I.
- **3** The ketene can be converted back into **Z** by using water under suitable conditions.
- A 1 and 2 only
- B 1 and 3 only
- C 2 and 3 only
- **D** 1, 2 and 3

**28** Aqueous silver nitrate can be used to test for the presence of halogens in organic compounds. Which of the following compounds produces a precipitate most readily when aqueous silver nitrate is added?



**29** The Reimer–Tiemann reaction is a chemical reaction used for the orthoformylation of phenols, with the simplest example being the conversion of phenol to salicylaldehyde.



salicylaldehyde

Which of the following types of reaction are involved in the above reaction scheme?

- 1 Nucleophilic substitution
- 2 Electrophilic substitution
- 3 Elimination
- A 1 and 2 only
- B 1 and 3 only
- C 2 and 3 only
- **D** 1, 2 and 3

**30** Hydroboration is one of the many methods to hydrate alkenes to alcohols. An example is shown below.



Which of the following alcohols cannot be formed via hydroboration?

- A Butan-2-ol from but-1-ene
- B 2-methylpropan-1-ol from 2-methylpropene
- **C** 3-methylpentan-2-ol from 3-methylpent-2-ene
- D 4-methylhexan-3-ol from 3-methylhex-3-ene

# **END OF PAPER**