Candidate Number

Name

Anglo-Chinese School (Independent)



Year 6 PRELIMINARY EXAMINATION 2023 INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME CHEMISTRY HIGHER LEVEL

PAPER 1

Tuesday

12th September 2023

1 hour

Additional materials:

Multiple choice answer sheet Soft clean eraser Soft pencil (type 2B recommended)

INSTRUCTIONS TO CANDIDATES

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

Shade your Candidate number on the multiple choice answer sheet provided.

There are **forty** questions in this paper. Answer **all** the 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.

INFORMATION FOR CANDIDATES

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. A copy of the periodic table is provided for reference on Page 2 of the examination paper.

Calculators are **not** allowed to be used in this paper.



This question paper consists of <u>18</u> printed pages, including the cover page.

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τ-	н н 1.01			Ą	omic numl Flement	per												2 He 4.00	
м	3 Li 6.94	Be 9.01		Relati	ive atomic	mass						L	5 B 10.81	6 C 12.01	7 N 14.01	8 0 16.00	9 F 19.00	10 Ne 20.18	
ŝ	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95	
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 く 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.90	
5	37 Rb 85.47	38 Sr 87.62	39 ⊀ 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29	
9	55 Cs 132.91	56 Ba 137.33	57† La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 0s 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 TI 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)	
~	87 Fr (223)	88 Ra (226)	89‡ Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (269)	109 Mt (278)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Unt (286)	114 Uug (289)	115 Uup (288)	116 Uuh (293)	117 Uus (294)	118 Uuo (294)	
			+	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 H o 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97		
			++	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)		

- 1. In which of the following species would nitrogen be reduced if converted to N₂O₄?
 - $A. \quad NH_3$
 - B. NO
 - C. NO_3^-
 - $\mathsf{D}. \quad \mathsf{NO}_2^-$
- 2. How many electrons are needed when the following half-equation is balanced using the lowest possible whole numbers?

 $_SO_2 + _H_2O \rightarrow _SO_4^{2^-} + _H^+ + _e^-$ Α. 1 Β. 2 C. 3

- D. 4
- 3. Typically, when a person coughs, he first inhales about 2.0 dm³ of air at 1.0 atm and 25 °C. In the lungs, the air is warmed to 37 °C and compressed to a volume of about 1.7 dm³ by the action of the diaphragm and chest muscles. The sudden opening of the vocal cord then releases the air explosively.

Just prior to this release, what is the approximate pressure (in atm) of the gas inside the lungs?

- A. $\frac{1.0 \times 2.0 \times 37}{25 \times 1.7}$
- B. <u>1.0×2.0×310</u> 298×1.7
- C. 25×1.7 1.0×2.0×37
- D. 298×1.7 1.0×2.0×310

- Which of the following statements contains one mole of the stated particle? [At SATP, one mol of gas occupies 24.0 dm³]
 - A. Molecules in 19.00 g of fluorine gas.
 - B. Electrons in 24.0 dm³ of hydrogen gas at SATP.
 - C. Neutrons in 1.00 g of helium gas.
 - D. Protons in 2.018 g of neon gas.
- **5.** The first eight successive ionization energies for an atom are shown. In which group is the atom found?



D. 18

- 6. How many electrons are there in all the d orbitals in xenon atom?
 - A. 10
 - B. 18
 - C. 20
 - D. 36
- 7. Which trend is correct across the period?
 - A. Atomic radius decreases
 - B. Electronegativity decreases
 - C. Ionic radius increases
 - D. Melting point decreases
- **8.** Which of the following affects the colour of the complex formed by a particular transition metal?
 - I. Oxidation state of metal
 - II. Type of ligand
 - III. Geometry of the complex
 - A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

- **9.** Which of the following statements best explains why $[Fe(H_2O)F_5]^{2-}$ appears colourless?
 - A. The d orbitals are half-filled
 - B. The electrons do not undergo d-d transition.
 - C. The complex is octahedral in shape.
 - D. The energy gap between the d orbitals does not corresponds to radiation from the visible light region.
- **10.** Which of the following correctly show the strongest intermolecular forces of attraction for the compound?

	Compound	Strongest Intermolecular forces of
		attraction
Α.	CH_3CH_2F	Hydrogen bonding
В.	CH ₂ O	Dipole forces
C.	CH_2Cl_2	London dispersion force
D.	$C_6H_5CONH_2$	Dipole forces

- 11. Which species does not have resonance structures?
 - A. O₃
 - B. NO₃⁻
 - C. CH_3COCH_3
 - D. CO3²⁻

12. The structure shows the bonding in salicylic acid.



Which statements are correct?

- I The molecules do not form London dispersion forces between them.
- II The carbon atom is the carboxyl group is sp^2 hybridised.
- III The molecule can form intramolecular hydrogen bonding.
- A. I and II only
- B. I and III only
- C. II and III only
- D. All of the above
- 13. Which of the following compound contains the strongest ionic bond?
 - A. NaBr
 - B. NaCl
 - C. MgF₂
 - D. MgCl₂

14. A large excess of magnesium ribbon is added to dilute hydrochloric acid and the volume of hydrogen gas produced is measured as the reaction proceeds. The reaction is exothermic. The results are shown below.



Which explains the changes in the rate of reaction between points P and Q and between points Q and R?

•	between points P and Q	between points Q and R
(\mathbf{x})	the reaction temperature increases	the acid concentration decreases
В.	magnesium's surface area decreases	the acid concentration decreases
C.	the reaction temperature increases	the magnesium has been used up
D.	magnesium's surface area decreases	the magnesium has been used up

- **15.** When the temperature of a particular reaction is increased by 10 °C (e.g. from 20 °C to 30 °C) the rate of the reaction approximately doubles. What is the best reason for this increase?
 - A. A reduced activation energy for the reaction.
 - B More particles colliding at the energy greater than the activation energy.
 - C. An increased collision frequency of the reactant molecules.
 - D. A different mechanism for the reaction.

16. A student mixes 2.50 g of excess zinc powder with 25.0 cm³ of 0.350 mol dm⁻³ hydrochloric acid. The temperature increases by 3.5 °C. What is the enthalpy change for the reaction, in kJ mol⁻¹?

(specific heat capacity of water is 4.18 J g⁻¹ K⁻¹)

A.
$$\begin{array}{c} 27.5 \times 4.18 \times (3.5 + 273) \times 65.38 \\ 2.50 \times 1000 \end{array}$$

B.
$$\frac{25.0 \times 4.18 \times 3.5}{25.0 \times 0.35}$$

- C. $\frac{25.0 \times 4.18 \times 3.5 \times 65.38}{2.50 \times 1000}$
- D. $\begin{array}{c} 27.5 \times 4.18 \times (3.5 + 273) \\ 25.0 \times 0.35 \end{array}$
- 17. Which equation represents the average bond energy of the C-H bond in methane?

 - $C. \qquad CH_4 \ (g) \rightarrow C \ (g) + 4H \ (g)$
 - $\mathsf{D}. \qquad \mathsf{CH}_4 \ (\mathsf{g}) \to \mathsf{CH}_3 \ (\mathsf{g}) + \mathsf{H} \ (\mathsf{g})$
- **18.** The equation on an enthalpy change is shown.

2C (s) + 3H₂ (g) +
$$\frac{7}{2}$$
 O₂ (g) \rightarrow 2CO₂ (g) + 3H₂O (l)

Given the following equations,

$$\begin{split} & \mathsf{C} \ (\mathsf{s}) + \mathsf{O}_2 \ (\mathsf{g}) \to \mathsf{CO}_2 \ (\mathsf{g}) & \Delta H^{\mathsf{e}} = x \ \mathsf{kJ} \\ & \mathsf{H}_2 \ (\mathsf{g}) + \tfrac{1}{2} \ \mathsf{O}_2 \ (\mathsf{g}) \to \mathsf{H}_2 \mathsf{O} \ (\mathsf{l}) & \Delta H^{\mathsf{e}} = y \ \mathsf{kJ} \end{split}$$

What is correct expression for the enthalpy change of the reaction above?

A.
$$x + y + \Delta H_c^{\Theta}(O_2)$$

B.
$$2x + 3y + \frac{7}{2}\Delta H_c^{\theta}(O_2)$$

- C. 2y 3x
- D. 3y + 2x

- **19.** Which is correct for a reaction with a negative change in Gibbs free energy, ΔG° ?
 - A. The reaction has a negative ΔH° and ΔS° at 298 K.
 - B. The reaction becomes spontaneous at higher temperature.
 - C. The reaction has maximum entropy.
 - D. The formation of product is favoured.
- 20. In which reaction does entropy increase?
 - A. NaCl (aq) + AgNO₃ (aq) \rightarrow AgCl (s) + NaNO₃ (aq)
 - B. $H_2(g) + I_2(g) \rightarrow 2HI(g)$
 - C. $CaCO_3 (s) \rightarrow CaO (s) + CO_2 (g)$
 - D. $H_2O(l) \rightarrow H_2O(s)$
- 21. Propanone reacts with iodine in the presence of an acid.

$$\mathsf{CH}_3\mathsf{COCH}_3 + \mathrm{I}_2 \xrightarrow{\mathsf{H}^+} \mathsf{CH}_3\mathsf{COCH}_2\mathrm{I} + \mathsf{H}\mathrm{I}$$

The mechanism involves the following steps:

$$CH_3COCH_3 \xrightarrow{H^+} CH_3C(OH)CH_2$$
 (slow)

$$\label{eq:CH3} \mathsf{CH}_3\mathsf{C}(\mathsf{OH})\mathsf{CH}_2 + \mathrm{I}_2 \to \mathsf{CH}_3\mathsf{CI}(\mathsf{OH})\mathsf{CH}_2\mathrm{I} \tag{fast}$$

$$CH_3CI(OH)CH_2I \rightarrow CH_3COCH_2I + HI$$
 (fast)

Which conclusion cannot be drawn from this information?

- A. Iodine is not involved in the rate-determining step.
- B. The acid acts as a catalyst.
- C. The overall order of the reaction is 3.
- D. The rate of reaction is not affected by a change in the iodine concentration.

22. Ethyne can form benzene when heated.

$$3HC \equiv CH(g) \rightarrow C_6H_6(l)$$

This reaction is found to be exothermic. Which conclusion can you draw from this information?

- A. This reaction is spontaneous at all temperatures.
- B. This reaction is not spontaneous at all temperatures.
- C. This reaction is spontaneous at high temperatures.
- D. This reaction is spontaneous at low temperatures.
- **23.** The reaction 2X (g) + Y (g) \rightarrow 3Z (g) has the rate expression

rate =
$$k [X]^2 [Y]^0$$

The concentration of X is increased by a factor of three and the concentration of Y is increased by a factor of two. By what factor will the reaction rate increase?

- A. 6
- B. 9
- C. 12
- D. 18
- **24.** The Haber Process combines nitrogen from the air with hydrogen derived mainly from natural gas (methane) into ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$
 $K_c = y$

Determine the K_c of the following equilibrium: $\frac{1}{2} NH_3(g) \Rightarrow \frac{1}{4} N_2(g) + \frac{3}{4} H_2(g)$

A. $(y)^{0.25}$ B. $\frac{4}{y}$ C. $\left(\frac{1}{y}\right)^{0.25}$ D. $\left(\frac{1}{y}\right)^{0.5}$ 25. An aqueous solution of dichromate ions (Cr₂O₇²⁻) is orange, whilst an aqueous solution of chromate ions (CrO₄²⁻) is yellow. These two ions can be converted by the following reversible reaction.

 $2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$

Which of the following chemicals when added will change a yellow solution of CrO_4^{2-} into orange $Cr_2O_7^{2-}$?

- A. Add water
- B. Add aqueous Ba(OH)₂
- C. Add aqueous HNO₃
- D. Add aqueous NH₃
- **26.** Which of the following equilibrium composition is **not** affected when the total pressure is increased at a constant temperature?
 - A. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
 - B. $2NO_2(g) \rightleftharpoons N_2O_4(g)$
 - C. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
 - D. $CaCO_3 (s) \rightleftharpoons CaO (s) + CO_2 (g)$
- **27.** 10.0 cm³ of an aqueous solution of hydrochloric acid of pH = 3 is mixed with 990.0 cm³ of distilled water. What is the pH of the resulting solution?
 - A. 1
 - B. 2
 - C. 4
 - D. 5

- 28. What is the order of increasing pH for the following solutions of the same concentration?
 - A. HCl (aq) < H₂SO₄ (aq) < KNO₃ (aq) < CH₃COONa
 - B. KNO_3 (aq) < $CH_3COONa < H_2SO_4$ (aq) < HCl (aq)
 - C. H_2SO_4 (aq) < HCl (aq) < KNO₃ (aq) < CH₃COONa
 - D. H_2SO_4 (aq) < HCl (aq) < CH₃COONa < KNO₃ (aq)
- **29.** Methyl orange is a weak acid and has a p K_a of 3.7. The dissociation of methyl orange (HIn) can be represented by the following equation.

 $\begin{array}{l} HIn \; (aq) \rightleftharpoons H^{+} \; (aq) + In^{-} \; (aq) \\ Red & yellow \end{array}$

Which statement is correct?

- A. Methyl orange can be used as an indicator for the titration between sodium hydroxide and ethanoic acid.
- B. At pH 7, red will be observed.
- C. At pH 4, orange will be observed.
- D. At pH 1, the major species will be In^- (aq).
- **30.** Which has the strongest conjugate acid?
 - A. $NH_3 (pK_b = 4.75)$
 - B. CH_3NH_2 (p K_b = 3.34)
 - C. $C_6H_5NH_2$ (p K_b = 9.13)
 - D. $(CH_3)_3N (pK_b = 4.20)$

31. What is the E^{\ominus} value, in V, for the reaction Zn (s) + Ni²⁺ (aq) \rightarrow Zn²⁺ (aq) + Ni (s) deduced from the following equations?

Zn (s) + 2Ag⁺ (aq) → Zn²⁺ (aq) + 2Ag (s) $E^{\ominus} = 1.56$ V Ni (s) + Cu²⁺ (aq) → Ni²⁺ (aq) + Cu (s) $E^{\ominus} = 0.60$ V Cu (s) + 2Ag⁺ (aq) → Cu²⁺ (aq) + 2Ag (s) $E^{\ominus} = 0.46$ V

- A. 0.50
- B. 0.96
- C. 1.10
- D. 2.16
- **32.** What is the order of increasing mass deposited by this electrolytic cell when the molten salts are electrolysed?



- A. Ag < Co < Fe
- B. Fe < Co < Ag
- C. Co < Ag < Fe
- D. Co < Fe < Ag

. The following shows a reaction:



What could be the final products?









34. Testosterone is the primary sex hormone and anabolic steroid in males. How many enantiomers can Testosterone produce?



- A. 2⁵
- B. 2⁶
- C. 2⁷
- D. 2⁸

35. Which pair of reaction types is illustrated by the reaction sequence below?

 $CH_{3}CH=CHCH_{3} \xrightarrow{HI \text{ in } CH_{3}CO_{2}H} CH_{3}CH_{2}CHICH_{3} \xrightarrow{NaOH(aq)} CH_{3}CH_{2}CH(OH)CH_{3}$

- A. electrophilic addition and electrophilic substitution
- B. electrophilic addition and nucleophilic substitution
- C. nucleophilic addition and electrophilic substitution
- D. nucleophilic addition and nucleophilic substitution
- **36.** Ethene reacts with bromine to form dibromoethane. Which of the following best describes the intermediate in this reaction?
 - A. It can act as a nucleophile.
 - B. It is electron deficient.
 - C. Each carbon in the intermediate is sp² hybridised.
 - D. It contains delocalised electrons.



- A. 2
- B. 3
- C. 4
- D. 5

38. What is the ratio of the areas of the signals in the ¹H NMR spectrum of pentan-3-ol?

- A. 6:4:1:1
- B. 3:1:1:1
- C. 5:5:1:1
- D. 3:3:2:2:1:1

39. The volume and mass of different pieces of aluminium metal are measured independently. A graph of mass against volume is plotted as shown.



Which can be deduced from the results?

	density	significant error
Α.	3.000	random
В.	3.000	systematic
C.	3.200	random
D.	3.200	systematic

40. A student prepared a standard solution of aqueous sodium carbonate, by dissolving (0.200 ± 0.002) g of anhydrous Na₂CO₃ solid in 10 cm³ of deionised water in a (50 ± 5) cm³ beaker. The resulting solution is transferred into a (100.0 ± 0.10) cm³ volumetric flask and top up with deionised water to the 100 cm³ mark.

What is the percentage uncertainty of the prepared concentration?

- A. 1.1 %
- B. 2.0 %
- C. 6.0 %
- D. 11.1 %

END OF PAPER