Anglo-Chinese School (Independent)



# Year 5 Promotional Examination 2022 INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME CHEMISTRY HIGHER LEVEL

## PAPER 1

Monday

12<sup>th</sup> September 2022

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>19</u> printed pages, including the cover page.

								The	Perio	dic Ta	ıble							
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<b>*</b>	<b>– H</b> <sup>0</sup>			At	omic numt Flement	ber											L	2 <b>He</b> 4.00
(1)	ς. α Γ α Γ α α α α α α	4 86 9.01	Г	Relati	ive atomic	mass						<u> </u>	5 B 10.81	6 <b>C</b> 12.01	7 N 14.01	8 <b>O</b> 16.00	9 F 19.00	10 Ne 20.18
~7	11 22.9	12 12 19 24.31	[									<u> </u>	13 Al 26.98	14 Si 28.09	15 P 30.97	16 <b>S</b> 32.07	17 Cl 35.45	18 Ar 39.95
4	39.4 <b>7</b> 19	20 <b>Ca</b> 10 40.08	21 Sc 44.96	22 Ti 47.87	23 <b>V</b> 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 <b>Co</b> 58.93	28 Ni 58.69	29 Cu 63.55	30 <b>Zn</b> 65.38	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.63	33 <b>As</b> 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.90
43	37 37 85.4	. 38 38 17 87.62	39 ⊀ ≮ 88.91	40 Zr 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.96	43 <b>Tc</b> (98)	44 Ru 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 Sn 118.71	51 Sb 121.76	52 <b>Te</b> 127.60	53 I 126.90	54 Xe 131.29
Ű	55 <b>Cs</b> 132.(	56 Ba 91 137.3	57 † La 3 138.91	72 Hf 178.49	73 <b>Ta</b> 180.95	74 W 183.84	75 Re 186.21	76 <b>Os</b> 190.23	77 Ir 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 TI 204.38	82 <b>Pb</b> 207.2	83 Bi 208.98	84 <b>Po</b> (209)	85 At (210)	86 <b>Rn</b> (222)
~	87 Fr (223	88 <b>Ra</b> 3) (226)	89‡ Ac (227)	104 Rf (267)	105 <b>Db</b> (268)	106 <b>Sg</b> (269)	107 Bh (270)	108 <b>Hs</b> (269)	109 Mt (278)	110 <b>Ds</b> (281)	111 <b>Rg</b> (281)	112 Cn (285)	113 Unt (286)	114 <b>Uug</b> (289)	115 Uup (288)	116 Uuh (293)	117 Uus (294)	118 <b>Uuo</b> (294)
			÷	58 <b>Ce</b> 140.12	59 <b>Pr</b> 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 <b>o</b> 164.93	68 Er 167.26	69 Tm 168.93	70 <b>Yb</b> 173.05	71 Lu 174.97	
			#	90 Th 232.04	91 <b>Pa</b> 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 Cf (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 No (259)	103 Lr (262)	

- 1. What is the mass of methane (CH<sub>4</sub>) that contains  $4.80 \times 10^{23}$  atoms of hydrogen? Avogadro's constant, N<sub>A</sub>:  $6.02 \times 10^{23}$  mol<sup>-1</sup>
  - A. 2.4 g
  - B. 3.2 g
  - C. 12.8 g
  - D. 13.3 g
- 20 cm<sup>3</sup> of a gaseous hydrocarbon was burnt in 150 cm<sup>3</sup> of oxygen. After cooling to room temperature, the residual gaseous products occupied a volume of 110 cm<sup>3</sup>. The gas was then bubbled through aqueous calcium hydroxide, and it was reduced to 30 cm<sup>3</sup>. What is the molecular formula of the hydrocarbon?
  - A. C<sub>3</sub>H<sub>6</sub>
  - B. C<sub>3</sub>H<sub>8</sub>
  - C. C<sub>4</sub>H<sub>8</sub>
  - $D. \quad C_4 H_{16}$
- 3. Which element undergoes reduction in the following reaction?

 $(\mathsf{NH}_4)_2\mathsf{Cr}_2\mathsf{O}_7\ (s)\to\mathsf{N}_2\ (g)+4\mathsf{H}_2\mathsf{O}\ (l)+\mathsf{Cr}_2\mathsf{O}_3\ (s)$ 

- A. Cr
- В. Н
- C. N
- D. O

**4.** What is the coefficient for H<sup>+</sup> when the following equation is balanced using the smallest possible whole numbers?



5. Which graph correctly describes the behaviour of a fixed mass of an ideal gas? (*T* is measured in K.)



- B. I and III only
- C. II and III only
- D. I, II and III

**6.** Flask X contains 1 dm<sup>3</sup> of helium at 2.00 x 10<sup>3</sup> Pa and flask Y contains 2 dm<sup>3</sup> of neon at 1.00 x 10<sup>3</sup> Pa. The flasks are later connected at a constant temperature, what is the final pressure?



- A.  $1.33 \times 10^3$  Pa
- B.  $1.50 \times 10^3$  Pa
- $C. \qquad 1.67\times 10^3 \ Pa$
- $D. \qquad 2.00\times 10^3 \ Pa$
- 7. Which equation represents a reaction that occurs under standard conditions?
  - A. 2 LiBr (aq) +  $I_2$  (aq)  $\rightarrow$  2 LiI (aq) + Br<sub>2</sub> (aq)
  - B. 2 KF (aq) +  $Cl_2$  (aq)  $\rightarrow$  2 KCl (aq) +  $F_2$ (aq)
  - C. 2 LiCl (aq) +  $I_2$  (aq)  $\rightarrow$  2 LiI (aq) + Cl<sub>2</sub> (aq)
  - D.  $2KBr(aq) + Cl_2(aq) \rightarrow 2 KCl(aq) + Br_2(aq)$
- 8. Which combination of statements about the oxides of period 3 elements is correct?

	State a	at room tempe	erature	Electrical conductivity in molten state		
	Na <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	P <sub>4</sub> O <sub>10</sub>	Na <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	P <sub>4</sub> O <sub>10</sub>
Α.	solid	solid	gas	good	good	good
В.	solid	solid	solid	good	good	poor
C.	solid	liquid	liquid	good	poor	poor
D.	solid	solid	solid	poor	poor	good

- 9. Which statements about reactivity are correct?
  - I. Potassium reacts more vigorously than sodium with chlorine.
  - II. Lithium reacts more vigorously than potassium with water.
  - III. Fluorine reacts more vigorously than bromine with potassium iodide solution.
  - A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
  - **10.** Which ion is colourless?
    - A.  $[Sc(H_2O)_6]^{3+}$
    - B.  $[Cr(H_2O)_6]^{3+}$
    - C.  $[Fe(H_2O)_6]^{3+}$
    - D. [Fe(CN)<sub>6</sub>]<sup>3-</sup>
- **11.** Which statements are correct for the complex ion [Cu(EDTA)]<sup>2-</sup>?
  - I. The oxidation number of Cu in the complex ion is +2.
  - II. The coordination number of the Cu ion is 6.
  - III. The shape of the complex ion is linear.
  - A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III

- **12.** Which properties of transition elements are **not** shown by s-block elements such as calcium?
  - I. Transition metal ions have variable oxidation states.
  - II. Transition metal ions can act as oxidising agents in aqueous solution.
  - III. Transition metals can be used as catalysts for industrial processes.
  - A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
- **13.** Which combination correctly describes the geometry of  $XeF_3^+$ ?

	Electron domain geometry around Xe	Molecular geometry around Xe
Α.	Octahedral	T-shape
В.	Trigonal bipyramidal	Square planar
C.	Octahedral	Square planar
D.	Trigonal bipyramidal	T-shape

14. Which of the following pairs of molecules are both planar and polar?

- A. BeCl<sub>2</sub> and NO<sub>2</sub>
- B. SiO<sub>2</sub> and CO<sub>2</sub>
- C.  $BF_3$  and  $NH_3$
- D.  $ClF_3$  and  $SO_2$

- 15. Molecular dimerization can be described as the process in which two identical molecules combine to give a single product. Some examples of dimers include Al<sub>2</sub>Cl<sub>6</sub> and N<sub>2</sub>O<sub>4</sub>. Which of the following descriptions about the two dimers is **incorrect**?
  - A.  $Al_2Cl_6$  is a planar molecule.
  - B. The nitrogen–oxygen bond angle is 120°.
  - C.  $Al_2Cl_6$  is formed by two dative bonds between Al and Cl.
  - D.  $N_2O_4$  is a non-polar molecule.
- **16.** Trimethoprim (TMP) is used for the treatment and prevention of urinary tract infection. It has the following structure.



In which sequence is the bond angles quoted in decreasing order?

- A. x > y > w > z
- B. x > y > z > w
- C. y > w > z > x
- D. y > z > w > x

**17.** The standard enthalpy changes for two reactions are given below.

4Ag (s) + O<sub>2</sub> (g) 
$$\rightarrow$$
 2Ag<sub>2</sub>O (s)  $\Delta H^{\ominus} = -62 \text{ kJ}$   
C (s) + O<sub>2</sub> (g)  $\rightarrow$  CO<sub>2</sub> (g)  $\Delta H^{\ominus} = -394 \text{ kJ}$ 

What is the standard enthalpy change in kJ when 108 g of silver is obtained from the reduction of silver(I) oxide?

$$2Ag_2O(s) + C(s) \rightarrow 4Ag(s) + CO_2(g)$$

- A. –332
- В. –83
- C. –456
- D. -114
- **18.** Four reactions of the type shown are studied at the same temperature.

$$X (g) + Y (g) \rightarrow Z (g)$$

Which is the correct reaction pathway diagram for the reaction that would proceed most rapidly and with good yield?



**19.** The standard enthalpy change for this reaction is  $+142 \text{ kJ mol}^{-1}$ .

$$\frac{3}{2}O_{2}(g) \to O_{3}(g)$$

What is the bond enthalpy of the oxygen-oxygen bond in  $O_3$ , given that the bond enthalpy of O=O is 498 kJ mol<sup>-1</sup>?

- A.  $\frac{498 (142)}{2}$ B.  $\frac{498 + (142)}{3}$ C.  $\frac{\frac{3}{2} \times 498 - (142)}{2}$ D.  $\frac{\frac{3}{2} \times 498 - (142)}{3}$
- 20. Which processes are more exothermic for Mg than that of Ca?

I. 
$$X(g) \rightarrow X(s)$$

- II.  $X^{2+}(g) + O^{2-}(g) \rightarrow XO(s)$
- III.  $X^{2+}(g) \rightarrow X^{2+}(aq)$
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III
- **21.** Hand warmers, when activated, generate their warmth by the spontaneous crystallisation of sodium ethanoate from a supersaturated solution.

Which row describes the entropy changes involved?

	$\Delta \mathcal{S}_{system}$	$\Delta \mathcal{S}_{ ext{surroundings}}$	$\Delta S_{ ext{universe}}$
A.	decrease	decrease	decrease
B.	decrease	increase	increase
C.	increase	decrease	increase
D.	increase	increase	decrease



22. The Born-Haber cycle for barium oxide is shown below:

Which value represents the first electron affinity of oxygen atom, in kJ mol<sup>-1</sup>, given that the second electron affinity is +753 kJ mol<sup>-1</sup>?

- A. (299 + 1468 + 175) + (-554) + 3054 + 753
- B. (299 + 1468 + 175) + (-554) + 3054 753
- C. 3054 175 299 1468 (-554) 753
- D. 3054 175 299 1468 (-554) + 753

**23.** When steam is condensed, 44000 Jmol<sup>-1</sup> of heat is given off.

What is the entropy change, in  $JK^{-1}$ , when 1 mole of steam is condensed at 100°C and 1 bar pressure?

$$H_2O(g) \rightleftharpoons H_2O(l)$$

B. 
$$+\frac{44000}{373}$$
  
C.  $-\frac{44000}{100}$   
D.  $-\frac{44000}{100}$ 

+ -

Α.

44000 100

373

24. In the late 1700s, Becher proposed the phlogiston theory which stated that combustible materials contain phlogiston. When burnt, these materials release phlogiston into the air. A more combustible material contains more phlogiston.

Lavoisier and others eventually put forward the oxygen theory as a better explanation of combustion observations. This theory suggested that burning something meant reacting it with oxygen in the air.

This can be considered as a *paradigm shift*.

Which statements are correct about 'paradigm shift'?

- I. New empirical evidence is one factor that can lead to paradigm shifts.
- II. It is a change in the understanding of essential scientific concepts.
- III. It supports the fact that scientific theories can be proven.
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

- 25. Which of the following will not increase the rate of a reaction in an aqueous solution?
  - A. Increasing temperature in an endothermic reaction
  - B. Increasing the surface area of a solid reactant added to the solution
  - C. Increasing the pressure on the aqueous solution
  - D. Increasing the rate of stirring on the reaction mixture
- 26. Which of the following factors will affect the rate of a chemical reaction?
  - I. The frequency at which the reactants collide effectively.
  - II. The orientation of the reactants when the reactants collide.
  - III. The kinetic energy at which the particles collide.
  - A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
- **27.** Which properties can be monitored to determine the rate of reaction for the chemical reaction below?

 $5H_2O_2 + 2MnO_4^- + 6H^+ \rightarrow 5O_2 + 2Mn^{2+} + 8H_2O$ 

- I. Change in pH
- II. Change in colour
- III. Change in mass
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

28. The graph shows the distribution of kinetic energies for a reaction involving two gases.



29. The following reaction is first order with respect to P and second order with respect to Q.

 $\mathbf{P} + \mathbf{Q} \rightarrow \mathbf{R} + \mathbf{S}$ 

Which of the following statements is correct?

- A. The reaction occurs in a one-step mechanism.
- B. The reaction has an overall order of 3.
- C. The unit for rate constant in the rate equation is mol<sup>3</sup> dm<sup>-9</sup>.
- D. The initial rate of reaction doubles when the initial concentration of **Q** doubles.

**30.** Ethyl ethanoate, CH<sub>3</sub>CO<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>, undergoes a slow acid-catalysed hydrolysis in water where the concentration of acid in the solution remains constant. The rate equation is found to be

rate = 
$$k$$
[CH<sub>3</sub>CO<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>]

When large excess of HCl is reacted with 0.1 mol  $dm^{-1}$  of ethyl ethanoate, the half-life was found to be 62 min.

Another reaction was repeated using 0.2 mol dm<sup>-3</sup> of ethyl ethanoate. How long does it take for the concentration of ethyl ethanoate to fall to 0.0125 mol dm<sup>-3</sup>?

- A. 62 min
- B. 124 min
- C. 186 min
- D. 248 min
- 31. Experiments were conducted to investigate the rate equation involving reactants X and Y.

$$2\mathbf{X} + \mathbf{Y} \rightarrow \mathbf{W} + \mathbf{Z}$$

Two graphs were plotted based on the experimental results obtained.



What is the rate equation for the reaction?

- A. rate = k[X]
- B. rate = k[Y]
- C. rate =  $k[\mathbf{X}][\mathbf{Y}]$
- D. rate =  $k[\mathbf{X}][\mathbf{Y}]^2$

- 32. Which is the first step in the CFC-catalysed destruction of ozone in UV light?
  - $\mathsf{A.} \qquad \mathsf{CClF}_2 \to \mathsf{CClF}_{2^+} + \mathsf{Cl}^-$
  - B.  $CClF_2 \rightarrow CClF_2 + Cl$
  - C.  $CClF_2 \rightarrow CCl_2F^+ + F^-$
  - D.  $CClF_2 \rightarrow CCl_2F + F^{\bullet}$
- **33.** In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at a pressure of 200 atm.

What is the reason for this change?

- A. An iron catalyst is used.
- B. Maintaining the higher pressure is more expensive.
- C. The equilibrium yield of ammonia is increased at lower pressure.
- D. The rate of the reaction is increased at lower pressure.
- **34.** If  $N_2O_4$  gas is placed in a sealed vessel, the following equilibrium is established.

$$N_2O_4$$
 (g)  $\rightleftharpoons 2NO_2$  (g)

The forward reaction is endothermic.

Which of the following is true when the temperature is increased?

- I. The equilibrium constant increases.
- II. The concentration of NO<sub>2</sub> increases.
- III. The rate of the reverse reaction increases.
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

#### **35.** Given that,

Equilibrium I:	$C(s) + O_2(g) \Longrightarrow CO_2(g)$	$K_{c1} = 3$
Equilibrium II:	$C(s) + \frac{1}{2}O_2(g) \Longrightarrow CO(g)$	$K_{c2} = 2$
Equilibrium III:	$CO(g) + \frac{1}{2}O_2(g) \Longrightarrow CO_2(g)$	$K_{\rm c} = ?$

What is the numerical  $K_c$  value for the Equilibrium III?

A. 
$$\frac{\sqrt{2}}{3}$$
  
B.  $\frac{2}{3}$   
C.  $\frac{\sqrt{3}}{2}$   
D.  $\frac{3}{2}$ 

- **36.** Which of the following reaction is true for a reaction with a  $K_c$  value of  $1.00 \times 10^{-5}$  at 298 K?
  - I. There are more reactants than products at equilibrium.
  - II. The reaction is non-spontaneous at 298 K.
  - III.  $\Delta G^{\ominus}$  value changes with temperature.
  - A. I and II only
  - B. I and III only
  - C. II and III only
  - D. I, II and III
- 37. Which combination describes the system at equilibrium?

	Entropy	Gibbs free energy
A.	minimum	maximum
В.	minimum	minimum
C.	maximum	maximum
D.	maximum	minimum

38. Two compounds X and Y react to produce compound Z. The reaction is reversible.

 $\textbf{X} + \textbf{Y} \rightleftharpoons \textbf{Z}$ 

When **X** and **Y** are mixed in a closed system, a dynamic equilibrium is gradually established.

Which graph could represent the change in the rate of the forward and reverse reactions over time?



**39.** A student measured the change in mass on heating a sample of magnesium nitrate, Mg(NO<sub>3</sub>)<sub>2</sub> (s). What is the mass loss?

Mass before heating:  $(2.347 \pm 0.001)$  g Mass after heating:  $(1.997 \pm 0.001)$  g

- A. (0.35 ± 0.001) g
- B. (0.35 ± 0.002) g
- C. (0.350 ± 0.002) g
- D.  $(0.350 \pm 0.001)$  g

40. A group of students attempted to estimate the concentration of a solution of Fe<sup>2+</sup> by pipetting fixed volumes of the solution into a flask, adding an excess of dilute sulfuric acid, and then titrating with a standard solution of potassium manganate(VII) from a burette. The volume of KMnO<sub>4</sub> solution required by one student was 0.2 cm<sup>3</sup> lower than that of the other students.

Which of the following is a possible explanation for this discrepancy?

- A. The last drop of  $Fe^{2+}$  solution was blown from the pipette into the titration flask.
- B. The pipette was rinsed with deionised water instead of the solution of  $Fe^{2+}$  before the titration.
- C. The titration flask was rinsed with the solution of Fe<sup>2+</sup> instead of deionised water before the titration.
- D. The burette was rinsed with deionised water instead of the solution of KMnO<sub>4</sub> before the titration.