# Chemistry

## Higher level

## Paper 1A

2 hours [Paper 1A and 1B]

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**Instructions to candidates**

- Do not open the examination paper until instructed to do so.
- Answer all questions
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for paper 1A is **[40 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.

## Section A

1. Which of the following are pure substances?

   **I.** $Na(s)$

   **II.** $NaCl(aq)$

   **III.** $NaCl(s)$

   A. I and II only

   B. I and III only

   C. II and III only

   D. I, II and III

2. Which equation represents the deposition of $CO_2$?

   A. $CO_2(g) \rightarrow CO_2(aq)$

   B. $CO_2(s) \rightarrow CO_2(g)$

   C. $CO_2(g) \rightarrow CO_2(s)$

   D. $CO_2(s) \rightarrow CO_2(l)$

3. Which of the following electron transitions produces a line in the visible region of the electromagnetic spectrum?

   A. $n = 2$ to $n = 3$

   B. $n = 4$ to $n = 1$

   C. $n = 3$ to $n = 2$

   D. $n = 4$ to $n = 3$

4. Which statement is correct about the isotopes of carbon?

   A. They have the same numbers of neutrons.

   B. They have the same physical properties.

   C. They have different numbers of electrons.

   D. They have different mass numbers.

5. Which is the correct electron configuration of the chromium(III) ion, $Cr^{3+}$?

   A. $[Ar]\ 3d^3$

   B. $[Ar]\ 3d^2\ 4s^1$

   C. $[Ar]\ 3d^1\ 4s^2$

   D. $[Ne]\ 3d^3$

6. Which group of the periodic table does the element belong to based on the table of successive ionisation energies?

| **1st IE (kJ mol$^{-1}$)** | **2nd IE (kJ mol$^{-1}$)** | **3rd IE (kJ mol$^{-1}$)** | **4th IE (kJ mol$^{-1}$)** | **5th IE (kJ mol$^{-1}$)** | **6th IE (kJ mol$^{-1}$)** | **7th IE (kJ mol$^{-1}$)** |
|---|---|---|---|---|---|---|
| 1012 | 1907 | 4964 | 6274 | 21267 | 25431 | 29872 |

   A. 14

   B. 4

   C. 15

   D. 2

7. Which of the following samples contains the greatest number of oxygen atoms at STP?

   A. 0.50 mol $CuSO_4.5H_2O$

   B. 22.7 $dm^3$ $CO_2$

   C. $1.20 \times 10^{24}$ $H_2O$ water molecules

   D. 64 g $O_2$

8. Which statement explains the deviation of a real gas from ideal gas behaviour at very high pressures?

   A. Real gases have no intermolecular forces

   B. Real gases have a finite volume

   C. Real gases have no mass

   D. Real gases at STP contain equal numbers of particles

9. What is the correct formula for the compound iron(III) phosphate?

   A. $Fe_2PO_4$

   B. $Fe_2(PO_4)_3$

   C. $Fe_3(PO_4)_2$

   D. $FePO_4$

10. Which of the following are the properties of an ionic compound?

| | Melting Point | Solubility in water | Electrical conductivity |
|---|---|---|---|
| A. | Low | Insoluble | When molten |
| B. | High | Soluble | When molten |
| C. | High | Insoluble | When molten |
| D. | Low | Soluble | When solid |

11. Which statements are correct about covalent bonds?

I. A double covalent bond consists of three shared pairs of electrons

II. Single covalent bonds are longer than triple covalent bonds

III. Double covalent bonds are weaker than triple covalent bonds

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

12. Which is correct about the molecule $OF_2$?

| | Molecular geometry | Electron domain geometry | Bond angle |
|---|---|---|---|
| A. | Bent | Tetrahedral | $<109.5^{o}$ |
| B. | Bent | Trigonal planar | $<109.5^{o}$ |
| C. | Tetrahedral | Bent | $180^{o}$ |
| D. | Bent | Tetrahedral | $180^{o}$ |

13. Which is correct about the electron domain geometry hybridisation and bond angle of the carbon atoms in ethyne, $C_2H_2$?

| | **Electron domain geometry** | **Hybridisation** | **Bond angle** |
|---|---|---|---|
| A. | Linear | $sp^2$ | $180^o$ |
| B. | Linear | sp | $180^o$ |
| C. | Tetrahedral | sp | $120^o$ |
| D. | Tetrahedral | $sp^2$ | $120^o$ |

14. Which species are responsible for the electrical conductivity of metals?

    A. Mobile ions

    B. Lone pairs of electrons

    C. Delocalised electrons

    D. Atoms with unpaired electrons

15. What is the bonding between two atoms that have electronegativity values of 1.3 and 2.6? Use section 17 of the chemistry data booklet.

    A. Covalent

    B. Polar covalent

    C. Metallic

    D. Ionic

16. Which element has properties of both a metal and a non-metal element?

A. Na

B. N

C. Si

D. Zn

17. What is correct in order of increasing ionic radius?

A. $N^{3-} < O^{2-} < F^{-} < Na^{+}$

B. $Na^{+} < O^{2-} < F^{-} < N^{3-}$

C. $Na^{+} < F^{-} < O^{2-} < N^{3-}$

D. $Na^{+} < F^{-} < N^{3-} < O^{2-}$

18. Which of the following contains a sulfur atom with a +6 oxidation state?

I. $SO_3$

II. $SO_4^{2-}$

III. $Na_2S_2O_3$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

19. Which of the following explains why hydrated iron(II) sulfate is green?

    A. Green light is emitted when electrons return to lower energy d-orbitals
    B. Green light is absorbed when electrons return to lower energy d-orbitals
    C. The complementary colour to green light is emitted when electrons are promoted to higher energy d-orbitals
    D. The complementary colour to green light is absorbed when electrons are promoted to higher energy d-orbitals

20. Which of the following compounds are members of the same homologous series?

A. $CH_3CH_3$, $CH_3CHCH_2$, $CH_3CH_2CH_2CH_3$, $CH_3CH_2CH_2CH_2CH_3$

B. $HCOOH$, $HCOOCH_3$, $HCOOCH_2CH_3$, $HCOOCH_2CH_2CH_3$

C. $CH_3CHO$, $CH_3CH_2OH$, $CH_3CH_2CH_2OH$, $CH_3CH_2CH_2CHO$

D. $CH_2CHCH_3$, $CH_2CHCH_2CH_3$, $CH_2CHCH_2CH_2CH_3$, $CH_2CHCH_2CH_2CH_2CH_3$

21. Which compounds are functional group isomers?

    A. Propanoic acid and propanone
    B. Propanal and propanone
    C. Propan-1-ol and propan-2-ol
    D. Propane and propene

22. Which describes an endothermic reaction?

| | **Δ*H*** | **More stable** | **Higher potential energy** |
|---|---|---|---|
| A. | Positive | Reactants | Products |
| B. | Positive | Products | Reactants |
| C. | Negative | Reactants | Products |
| D. | Negative | Products | Reactants |

23. Which describes an endothermic reaction?

| | **Δ*H*** | **More stable** | **Higher potential energy** |
|---|---|---|---|
| A. | Positive | Reactants | Products |
| B. | Positive | Products | Reactants |
| C. | Negative | Reactants | Products |
| D. | Negative | Products | Reactants |

24. What volume of $CO_2(g)$ can be produced in the reaction of 8 $dm^3$ of $CO(g)$ and 8 $dm^3$ of $O_2(g)$ at STP?

A. 4 $dm^3$

B. 2 $dm^3$

C. 8 $dm^3$

D. 16 $dm^3$

25. Which involves the largest increase in entropy?

A. $LiBr(aq) \rightarrow LiBr(s)$

B. $H_2O_2(l) \rightarrow H_2(g) + O_2(g)$

C. $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

D. $H_2(g) + I_2(g) \rightarrow 2HI(g)$

26. What is the $\Delta H$ for the reaction shown in kJ $mol^{-1}$?

$$C_6H_6(l) + 7½O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$$

| | $C_6H_6(l)$ | $CO_2(g)$ | $H_2O(l)$ |
|---|---|---|---|
| **$\Delta H_f$ / kJ $mol^{-1}$** | +49 | −394 | −286 |

A. −729

B. 3271

C. −3271

D. 729

27. Which equation represents the lattice enthalpy of calcium chloride, $CaCl_2$?

A. $CaCl_2(s) \rightarrow Ca^{2+}(g) + 2Cl^-(g)$

B. $CaCl_2(g) \rightarrow Ca^{2+}(g) + 2Cl^-(g)$

C. $CaCl_2(s) \rightarrow Ca^{2+}(s) + 2Cl^-(s)$

D. $CaCl_2(s) \rightarrow Ca^{2+}(g) + Cl^-(g)$

28. Which of the following combinations would result in the fastest rate of formation of hydrogen gas, $H_2(g)$?

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

| | Mg(s) | HCl(aq) |
|---|---|---|
| A. | 2.00 g powder | 25 $cm^3$ 1.00 mol $dm^{-3}$ |
| B. | 2.00 g ribbon | 25 $cm^3$ 1.00 mol $dm^{-3}$ |
| C. | 2.00 g ribbon | 25 $cm^3$ 2.00 mol $dm^{-3}$ |
| D. | 2.00 g powder | 25 $cm^3$ 2.00 mol $dm^{-3}$ |

29. Which statements are correct about the rate equation shown?

$$\text{Rate} = k[A][B]^2$$

I. The reaction is second-order with respect to B

II. The reaction is third-order overall

III. Doubling [A] doubles the rate of reaction

A. I and II only

B. I and III only

C. II and III only

30. Which change will shift the equilibrium position to the left and decrease the value of the equilibrium constant, *K*, for the reaction shown?

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

A. Decreasing the pressure

B. Increasing the concentration of $NH_3$

C. Increasing the temperature

D. Decreasing the temperature

31. Which is correct for a spontaneous reaction?

| | $\Delta G^{\ominus}$ | $K$ | **Composition of reaction mixture** |
|---|---|---|---|
| A. | – | <1 | Mostly products |
| B. | + | >1 | Mostly reactants |
| C. | – | >1 | Mostly products |
| D. | – | >1 | Mostly reactants |

32. Which of the following is a conjugate acid-base pair?

A. $HClO$ and $H_2O$

B. $H_3O^+$ and $OH^-$

C. $H_2CO_3$ and $CO_3^{2-}$

D. $HSO_4^-$ and $SO_4^{2-}$

33. Which of the following will form an acidic buffer solution when mixed in appropriate molar ratios?

A. $NaOH$ and $CH_3COONa$

B. $NH_3$ and $NH_4Cl$

C. $CH_3COOH$ and $CH_3COONa$

D. $HCl$ and $CH_3COONa$

34. Which is correct about the redox reaction shown?

$$Mg(s) + 2AgNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + 2Ag(s)$$

| | **Reducing agent** | **Species reduced** |
|---|---|---|
| A. | $Mg(s)$ | $Ag^+(aq)$ |
| B. | $Ag^+(aq)$ | $Mg(s)$ |
| C. | $Ag(s)$ | $Mg^{2+}(aq)$ |
| D. | $Mg^{2+}(aq)$ | $Ag^+(s)$ |

35. Which is correct for a voltaic cell and an electrolytic cell?

I. Oxidation occurs at the anode

II. The $\Delta G^{\ominus}$ is negative

III. The cathode is positive and the anode is negative

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

36. Which compound can undergo oxidation to form a ketone?

A. $CH_3CH_2CHO$

B. $CH_3CH(OH)CH_3$

C. $CH_3CH_2CH_2OH$

D. $CH_3COCH_3$

37. Which species is formed during homolytic fission?

A. A positive ion

B. A negative ion

C. A radical

D. A leaving group

38. Which of the following occurs when ethene reacts with hydrogen?

A. Nucleophilic substitution

B. Electrophilic substitution

C. Nucleophilic addition

D. Electrophilic addition

39. Which statements are correct for the $S_N1$ mechanism?

I. Tertiary halogenoalkanes react via the $S_N1$ mechanism

II. The rate of reaction is directly proportional to the [Nu]

III. The reaction involves the formation of a carbocation intermediate

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

40. Which is correct about the reaction between $^{+}NO_2$ and $C_6H_6$?

A. The reaction occurs via electrophilic addition

B. $C_6H_6$ acts as a Lewis acid

C. The product of the reaction is $C_6H_5NO_2$

D. $^{+}NO_2$ acts as a catalyst