

SECTION A: MULTIPLE CHOICE
USE THE ANSWER SHEET PROVIDED

1. Which of the following molecules contains 36.86% nitrogen by mass?
- A. NO
 - B. N₂O**
 - C. N₂O₃
 - D. N₂O₄
 - E. N₂O₅
2. Which of the following lists elements in order of increasing atomic radius?
- A. K, Se, Cl
 - B. K, Cl, Se
 - C. Se, Cl, K
 - D. Se, K, Cl
 - E. Cl, Se, K**
 - F. Cl, K, Se
3. What is the total number of valence electrons in the S₄O₆²⁻ ion?
- A. 58
 - B. 60
 - C. 62**
 - D. 82
 - E. 224

4. Which of the following has a bond angle closest to 120° ?
- A. CO_2
 - B. PCl_3
 - C. SCl_2
 - D. CCl_4
 - E. BCl_3
5. Which of the following lists substances in order of increasing boiling point?
- A. $\text{Cl}_2, \text{SCl}_2, \text{MgCl}_2$
 - B. $\text{Cl}_2, \text{SCl}_2, \text{MgCl}_2$
 - C. $\text{MgCl}_2, \text{Cl}_2, \text{SCl}_2$
 - D. $\text{SCl}_2, \text{Cl}_2, \text{MgCl}_2$
 - E. $\text{SCl}_2, \text{MgCl}_2, \text{Cl}_2$
 - F. $\text{Cl}_2, \text{MgCl}_2, \text{SCl}_2$
6. Limestone (CaCO_3) can be eroded by acids. What volume (in mL) of 11.5 mol L^{-1} nitric acid (HNO_3) is required for complete reaction with 24.7 g of limestone?
- A. 10.7 mL
 - B. 11.5 mL
 - C. 21.5 mL
 - D. 42.9 mL
 - E. 85.8 mL

Questions 7 relates to the following information.

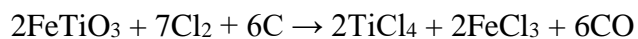
Effusion refers to the process where a gas passes from a container, through a very small hole, into a vacuum. The rate at which different gases effuse is inversely proportional to the square roots of their relative molecular masses. Mathematically,

$$\frac{\text{rate of effusion of gas A}}{\text{rate of effusion of gas B}} = \sqrt{\frac{M_B}{M_A}}$$

where M_A and M_B are the relative molecular masses of A and B

7. A mixture containing equal amounts of S_2F_2 and SF_4 is allowed to effuse from a container, through a small hole, into a vacuum. What is the ratio of S_2F_2/SF_4 molecules present in the gas that first emerges?
- A. 0.89
B. 0.95
C. 0.97
D. 1.03
E. 1.06
F. 1.12
8. The complete combustion of ethanamine ($C_2H_5NH_2$) produces carbon dioxide, nitrogen and water. What amount of oxygen is required for the complete combustion of 1.00 mol of ethanamine?
- A. 1.75
B. 3.50
C. 3.75
D. 5.50
E. 7.50

9. The reaction of ilmenite (FeTiO_3) with chlorine and carbon can be used in the industrial production of titanium from ilmenite:



When 500 kg of FeTiO_3 , 850 kg of Cl_2 and 125 kg of C are mixed, which of these reactants is present in excess? **Select all that apply.**

A. FeTiO_3

B. Cl_2

C. C

10. Iodine monochloride (ICl) reacts with carbon-carbon double bonds (one ICl per double bond). If 0.105 g of a molecule of molar mass 304.5 g mol^{-1} reacts with exactly 0.224 g of ICl , how many carbon-carbon double bonds are present in the molecule?

A. 2

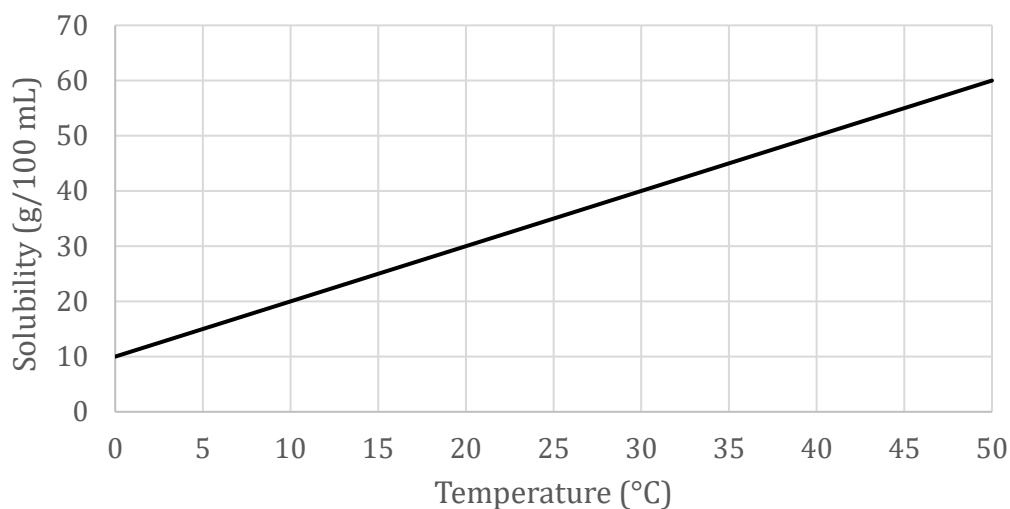
B. 3

C. 4

D. 5

E. 8

11. The following graph shows how the solubility of an unidentified substance changes with the temperature of the solution.



Using the graph, what mass of precipitate will be produced when 50 mL of a saturated solution at 40 °C is cooled to 10 °C?

- A. 15 g
 - B. 20 g
 - C. 25 g
 - D. 30 g
 - E. 50 g
12. First ionisation energy is defined as the energy required to remove one mole of electrons from one mole of gaseous ions. Which of the following lists elements in order of increasing first ionisation energy?

- A. He, O, F, N
- B. N, O, F, He
- C. He, N, O, F
- D. O, N, F, He
- E. He, F, O, N

13. What volume of 2.05 mol L^{-1} sodium chloride solution should be added to 1.06 L of 1.04 mol L^{-1} sodium chloride solution to make 2.22 L of 1.26 mol L^{-1} sodium chloride solution upon dilution to volume with water?

A. 0.49 L

B. 0.83 L

C. 0.96 L

D. 1.08 L

E. 1.16 L

14. A solid mixture of silver nitrate and an alkali metal nitrate was dissolved in a small volume of water. When an excess of an alkali metal halide was added to the solution, a silver halide precipitated from solution. After the precipitate was collected, weighed and dried, its mass was equal to the mass of the initial solid mixture.

Which of the following substances could be the alkali metal halide added? **Select all that apply.**

A. lithium fluoride

B. sodium chloride

C. potassium bromide

D. rubidium iodide

E. caesium chloride

15. A mineral has the formula $\text{Na}_2\text{Ca}_4\text{X}(\text{PO}_4)_3$, where **X** is an unspecified species. Which of the following could **X** be?

A. F^-

B. Ba^{2+}

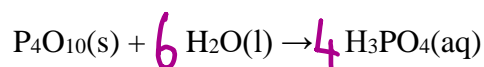
C. Ag^+

D. SO_4^{2-}

E. AsO_4^{3-}

Question 16

(a) Balance the following equation:



(b) When 4.585 g of P_4O_{10} reacts with water to produce 100 mL of H_3PO_4 solution, what concentration of H_3PO_4 (in mol L^{-1}) is this solution?

$$\begin{aligned} n(\text{P}_4\text{O}_{10}) &= \frac{4.585 \text{ g}}{283.88 \text{ g mol}^{-1}} = 0.01615 \text{ mol} \\ n(\text{H}_3\text{PO}_4) &= 0.01615 \text{ mol} \times 4 = 0.06460 \text{ mol} \\ \therefore [\text{H}_3\text{PO}_4] &= \frac{0.06460 \text{ mol}}{0.100 \text{ L}} = 0.646 \text{ mol L}^{-1} \end{aligned}$$

(c) An aliquot of this H_3PO_4 solution is titrated with NaOH with using thymolphthalein as an indicator. 23.03 mL of 1.122 mol L^{-1} NaOH are required. What chemical amount of NaOH is required? Express your answer in mol or mmol.

$$\begin{aligned} n(\text{NaOH}) &= 1.122 \text{ mmol mL}^{-1} \times 23.03 \text{ mL} \\ &= 25.84 \text{ mmol} \end{aligned}$$

(d) If the aliquot of H_3PO_4 solution had a volume of 20.00 mL, how many moles of NaOH are required per mole of H_3PO_4 ?

$$\begin{aligned} n(\text{H}_3\text{PO}_4) &= 0.646 \text{ mmol mL}^{-1} \times 20.00 \text{ mL} \\ &= 12.92 \text{ mmol} \\ \therefore n(\text{NaOH per H}_3\text{PO}_4) &= \frac{25.84 \text{ mmol}}{12.92 \text{ mmol}} = 2 \end{aligned}$$