

PART A: MULTIPLE CHOICE- (22 MARKS)

1. The chemical properties of atoms depend primarily upon

- A) the atomic masses of atoms
- B) the masses of the atoms
- C) the number of valence electrons
- D) the neutrons in the atom

2. Suppose that three isotopes of element X occur in nature as follows:

ISOTOPE	RELATIVE ATOMIC MASS	%
1	110.0	60.0
2	105.0	30.0
3	100.0	10.0

What is the average atomic mass of the naturally occurring mixture of element X?

- A) 102.3 u
- B) 107.5 u
- C) 112.5 u
- D) 108.0 u

3. Which of the following bonds would be the most polar?

- A) Ga-Cl
- B) Ga-Si
- C) Ga-P
- D) Ga-Br

4. As the atomic numbers of the elements in a family (group) of the Periodic Table increase, the

- A) atomic radii decrease
- B) atomic masses decrease
- C) ionization energies decrease
- D) metallic characteristics decrease

5. If X represents an element in group 13, its oxide will have the formula

- A) X_3O_2
- B) XO_4
- C) X_2O_3
- D) X_4O_3

6. The decomposition of mercury(II)oxide by heating can lead to the formation of

- A) mercury and oxygen
- B) mercury and nitrogen
- C) mercury(IV)oxide
- D) hydrogen and oxygen

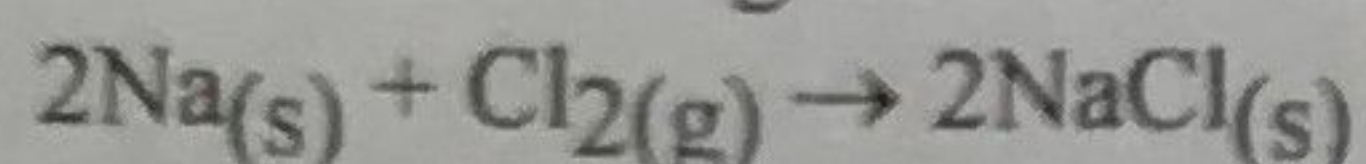
7. Which one of the following equations is balanced?

- A) $2 \text{KClO}_3 \longrightarrow \text{KCl} + 3 \text{O}_2$
- B) $\text{H}_2\text{O} + \text{Na} \longrightarrow \text{NaOH} + \text{H}_2$
- C) $\text{Zn} + \text{H}_2\text{SO}_4 \longrightarrow \text{ZnSO}_4 + 2 \text{H}_2$
- D) $2 \text{H}_2\text{O} + \text{Ca} \longrightarrow \text{Ca(OH)}_2 + \text{H}_2$

8. How many moles of SO_2 molecules are contained in 1.28 g of SO_2 ?

- A) 0.0200 mol
- B) 0.0500 mol
- C) 0.0100 mol
- D) 0.0250 mol

9. Consider the following balanced chemical equation:



If 4.12 mol of chlorine react with sodium metal, how many moles of sodium metal are consumed?

- A) 23.0 mol
- B) 8.24 mol
- C) 4.12 mol
- D) 2.06 mol

10. The number of atoms of oxygen in 205.5 g of $\text{Al}(\text{BrO}_3)_3$ is

- A) 3.010×10^{23}
- B) 9.030×10^{23}
- C) 1.806×10^{24}
- D) 2.709×10^{24}

11. The molecular mass of a compound with the simplest formula, NO_2 , is 92.0 g. The molecular formula of this compound

- is
- A) NO_2
- B) NO_4
- C) N_2O_4
- D) N_4H_8

12. The percentage yield of a particular reaction needs to be 82% for the reaction to be cost efficient. If the theoretical yield is 950 kg, what does the actual yield need to be?
- A) 171 kg
 - B) 779 kg
 - C) 950 kg
 - D) 1158 kg
13. The mass of solute, KCl, contained in 75.0 g of a 1.2% (m/m) KCl solution is:
- A) 0.90 g
 - B) 62 g
 - C) 9.0 g
 - D) 6.2 g
14. What volume of 6.0 mol/L $\text{HCl}_{(\text{aq})}$ is needed to prepare 300 mL of 0.030 mol/L solution?
- A) 1.5 mL
 - B) 15 mL
 - C) 3.0 mL
 - D) 30 mL
15. The conjugate acid of HPO_4^{2-} is
- A) PO_4^{3-}
 - B) HPO_4^{2-}
 - C) $\text{H}_2\text{PO}_4^{1-}$
 - D) H_3PO_4
16. If the $[\text{H}^+]$ is 1.5×10^{-8} , what is the pOH?
- A) 7.82
 - B) 6.18
 - C) 6.82
 - D) 7
17. The mass of solid $\text{Pb}(\text{NO}_3)_2$ required to prepare 0.125 L of a 0.4 mol/L solution of $\text{Pb}(\text{NO}_3)_2$ is
- A) 13.5 g
 - B) 16.6 g
 - C) 41.4 g
 - D) 331.0 g
18. Which one of the following statements is correct?
- A) the volume of a given mass of a gas (at constant pressure) varies inversely as its absolute temperature
 - B) when a gas is cooled the molecules move faster
 - C) at a constant volume an increase in pressure may be due to an increase in the number of molecules
 - D) the pressure exerted by a gas at a constant volume is independent of its temperature
19. The density of a gas at S.A.T.P. is 2.0 g/L. The relative molecular mass of this gas is most nearly
- A) 18.6 g/mol
 - B) 12.5 g/mol
 - C) 25.0 g/mol
 - D) 50.0 g/mol
20. The pressure of a fixed mass of gas is increased from 50 kPa to 200 kPa at constant temperature. What is the new volume of the gas?
- A) four times the original volume
 - B) one quarter the original volume
 - C) twice the original volume
 - D) half the original volume
21. What is the volume of 16.00 g of oxygen gas, O_2 , at STP?
- A) 24.8 L
 - B) 22.4 L
 - C) 11.2 L
 - D) 44.8 L
22. A rigid container contains 2.50 mol O_2 , 0.50 mol N_2 , and 1.00 mol CO_2 . The total pressure of the system is 200 kPa. The partial pressure exerted by the N_2 in the mixture is
- A) 25.0 kPa
 - B) 50.0 kPa
 - C) 100 kPa
 - D) 125 kPa

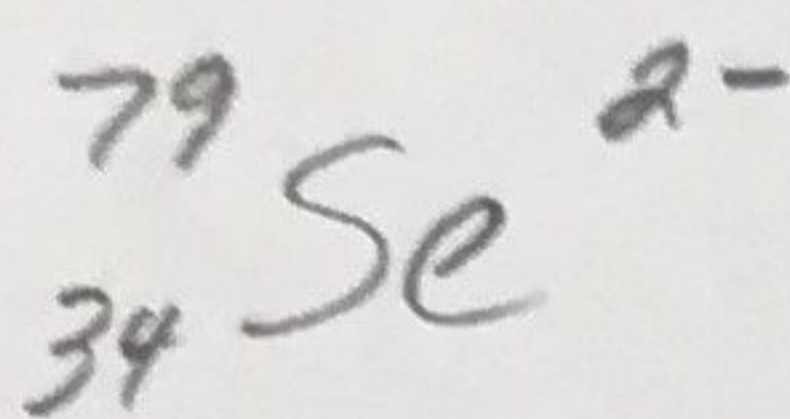
PART B: SHORT ANSWER / PROBLEM SOLVING

[52 MARKS]

Answer all questions in the space provided. FULL SOLUTIONS REQUIRED.

Be sure to include the correct number of significant digits and units where applicable.

1. a) Write the following in standard atomic notation and determine the number of subatomic particles: Selenide (2 marks)



p	34
e	36
n	45

- b) An experiment was carried out to determine the identity of an unknown element in the gaseous state. Various ionization energies were obtained for the element and the results were graphed below:

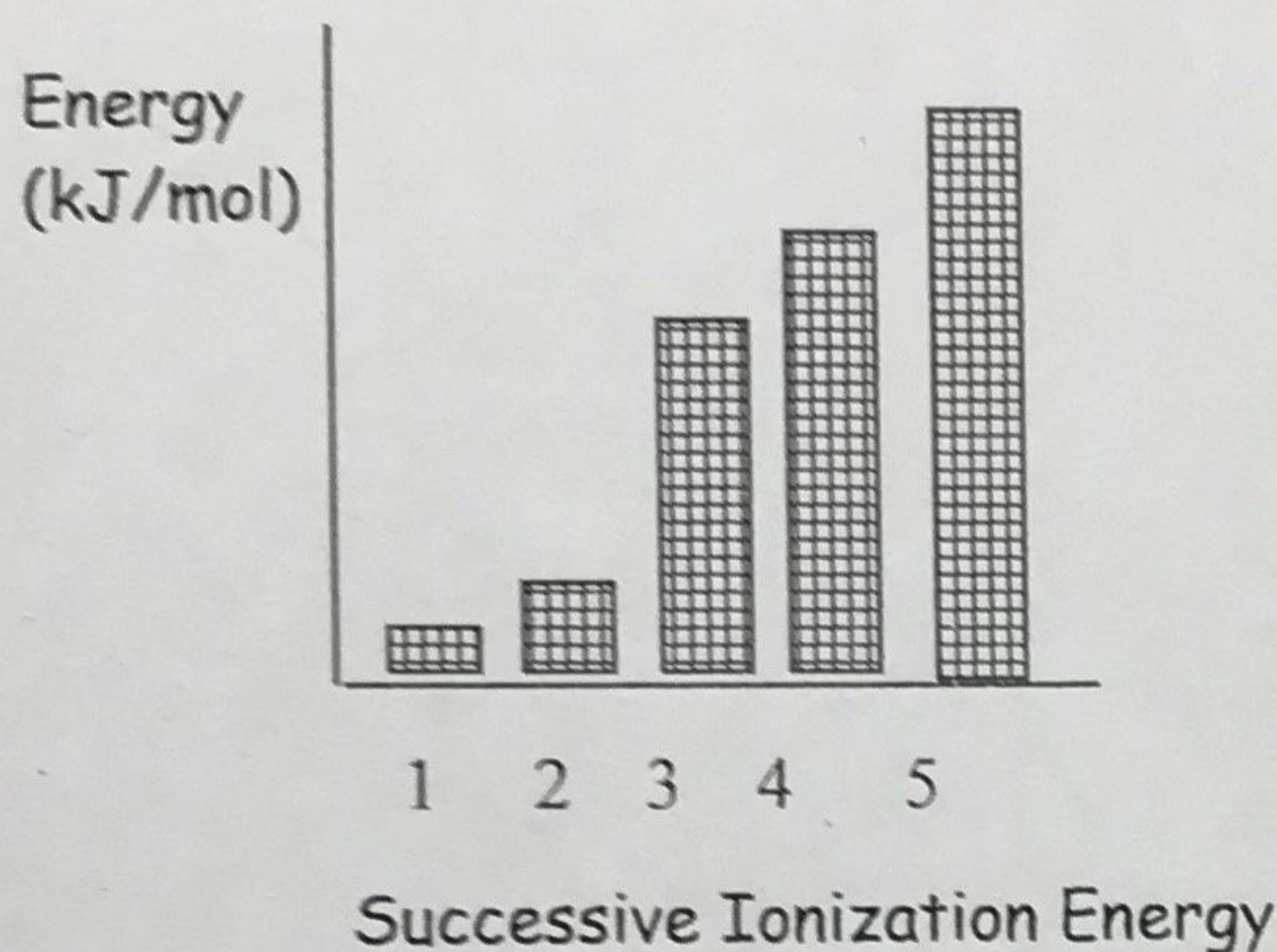


Figure 1 – Successive ionization energies of the unknown gaseous element.

Based on the data obtained, in which periodic group would you expect to find this unknown element? Be sure to provide thorough reasoning for your answer. (2 marks)

- Group 2
 - the first two IE are low, with a big jump for the third e⁻ removal

- c) The naturally occurring isotopes of Lithium are: Li-6.015121 u and Li-7.016003 u. Determine the percentage abundance of each isotope. (2 marks)

$$\text{let } x = \text{Li-6}$$

$$1-x = \text{Li-7}$$

$$\text{avg atomic mass} = 6.94 = (6.015121\text{u})(x) + (7.016003\text{u})(1-x)$$

$$6.94 = 6.015121x + 7.016003 - 7.016003x$$

$$1.000882x = 0.116003$$

$$x = 0.115900775$$

$$\therefore \text{Li-6} = 11.59\%$$

$$\text{Li-7} = 88.41\%$$

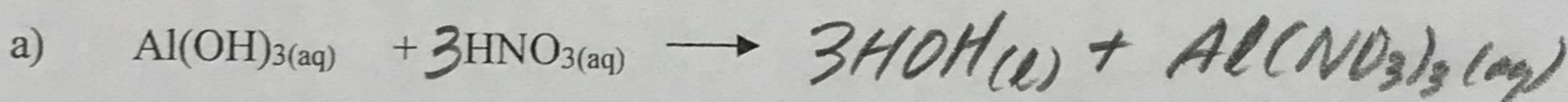
2. a) Name the following compounds (1 mark each, 5 marks total)

Chemical Formula	IUPAC Name
NH_3	nitrogen trihydride
$\text{SnS} \cdot 6\text{H}_2\text{O}$	tin(II) sulfide hexahydrate
$\text{HFO}_{(\text{aq})}$	hypofluorous acid
KOCN	potassium cyanate
$\text{H}_3\text{P}_{(\text{aq})}$	hydrophosphoric acid

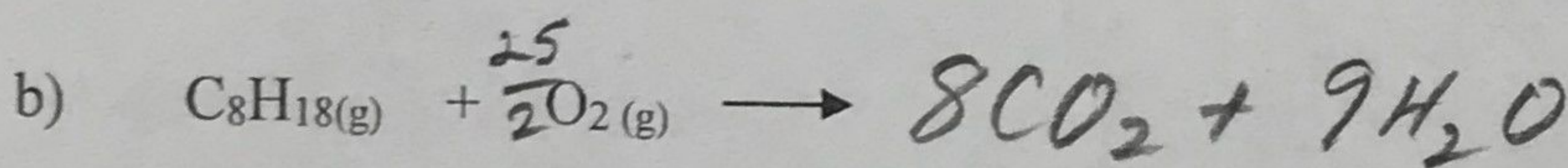
b) Draw the most appropriate Lewis structure for each of the following (2 marks each, 6 marks total)

i) CO_2	ii) $\text{Al}_2(\text{SO}_3)_3$
$\text{O}=\text{C}=\text{O}$	$2[\text{Al}]^{3+} \cdot 3 \left[\begin{array}{c} \text{O} \\ \\ \text{S} \\ \\ \text{O} \end{array} \right]^{2-}$ <p style="text-align: center;">↓ 2 others</p>
iii) HCN	
$\text{H}-\text{C} \equiv \text{N}$	

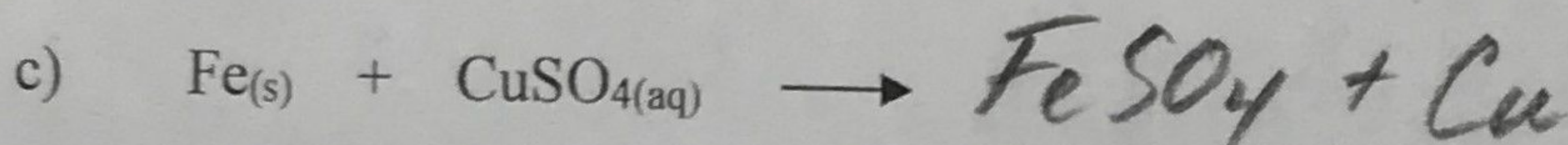
3. Complete the following chemical equations by writing in the correct products (including state) and balancing where necessary. Classify each reaction by stating the type (2 marks each, 10 marks total).



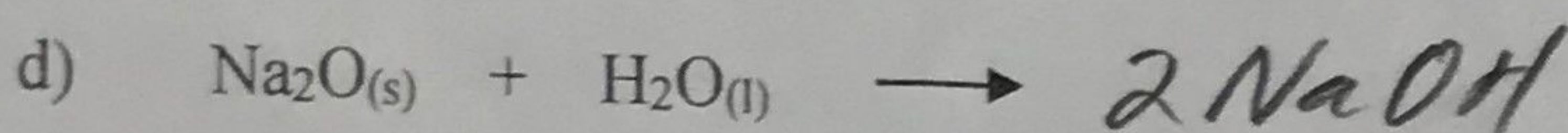
Reaction Type: double displacement



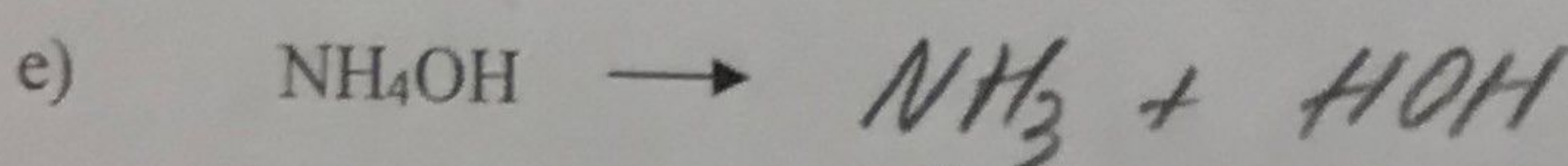
Reaction Type: combustion



Reaction Type: single displacement



Reaction Type: synthesis



Reaction Type: decomposition

4. Determine the number of formula units of 6.5 g of $\text{CaCl}_2 \cdot 7\text{H}_2\text{O}$ (_____ / 2 marks)

$$\frac{6.5 \text{ CaCl}_2 \cdot 7\text{H}_2\text{O}}{237.24 \text{ g}} \times \frac{1 \text{ mol}}{1 \text{ mol}} = \frac{6.02 \times 10^{23} \text{ fu}}{1 \text{ mol}}$$

ANS: $1.6 \times 10^{22} \text{ fu}$

make explicit that it has oxygen

5. A 1.0000 g sample of a compound is combusted in excess oxygen and the products are 2.492 g of CO_2 and 0.6495 g of H_2O . Given that its molar mass is 388.46 g/mol, determine the compound's molecular formula. (_____ / 4 marks)

$$\frac{2.492 \text{ g CO}_2}{44.01 \text{ g CO}_2} \times \frac{12.01 \text{ g C}}{1 \text{ mol C}} = 0.68 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 0.0566 \text{ mol C}$$

$$\frac{0.6495 \text{ g H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2.02 \text{ g H}}{1 \text{ mol H}} = 0.0728 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 0.072 \text{ mol H}$$

$$1.0000 \text{ g} - 0.68 \text{ g} - 0.0728 \text{ g} = 0.2472 \text{ g O} \times \frac{1 \text{ mol O}}{16 \text{ g O}} = 0.01545 \text{ mol O}$$

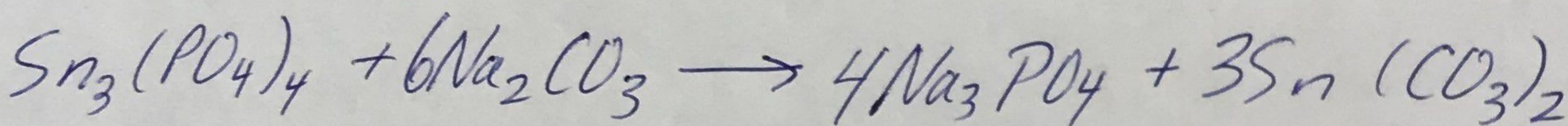
emp. formula is $\text{C}_{11}\text{H}_{14}\text{O}_3$

$$\frac{388.46 \text{ g/mol}}{194 \text{ g/mol}} = 2$$

$\therefore \text{C}_{22}\text{H}_{28}\text{O}_6$

ANS: $\text{C}_{22}\text{H}_{28}\text{O}_6$

6. If 25 g of tin(IV) phosphate is reacted with an equal amount of sodium carbonate, and 15.0 g of tin(IV) carbonate is actually produced, what is the percentage yield of the reaction? (_____ / 4 marks)



find LR:

$$\frac{25 \text{ g Sn}_3(\text{PO}_4)_4}{736.1 \text{ g}} \times \frac{1 \text{ mol Sn}_3(\text{PO}_4)_4}{1 \text{ mol Sn}_3(\text{PO}_4)_4} \times \frac{3 \text{ mol Sn}(\text{CO}_3)_2}{3 \text{ mol Sn}(\text{CO}_3)_2} = 0.10189 \text{ mol Sn}(\text{CO}_3)_2$$

$$\frac{25 \text{ g Na}_2\text{CO}_3}{106.01 \text{ g}} \times \frac{1 \text{ mol Na}_2\text{CO}_3}{1 \text{ mol Na}_2\text{CO}_3} \times \frac{3 \text{ mol Sn}(\text{CO}_3)_2}{6 \text{ mol Na}_2\text{CO}_3} = 0.1179 \text{ mol Sn}(\text{CO}_3)_2$$

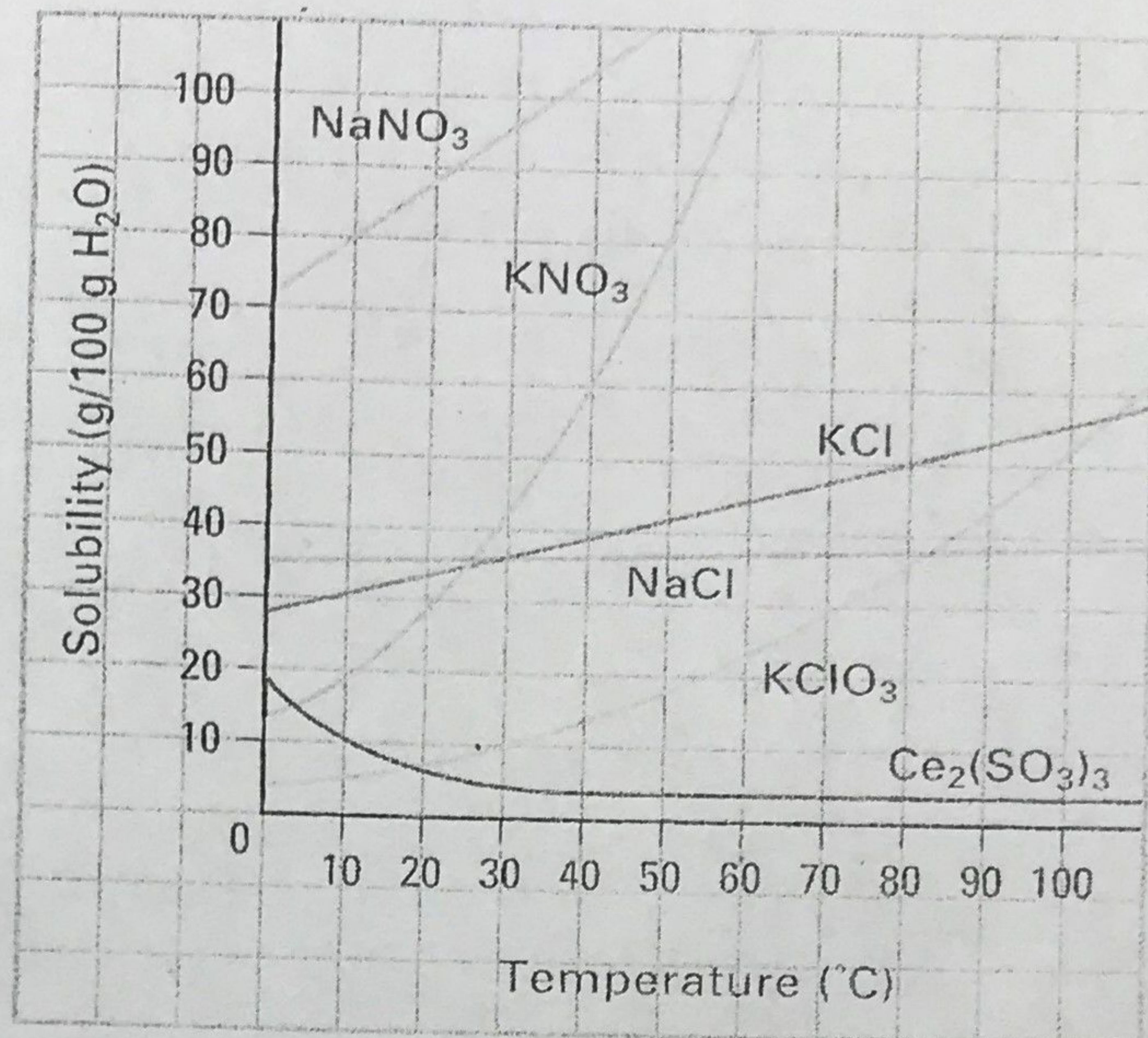
ANS: 62%

$$\text{then, } \frac{0.10189 \text{ mol Sn}(\text{CO}_3)_2}{1 \text{ mol}} \times 238.72 \text{ g} = 24.323 \text{ g (theoretical)}$$

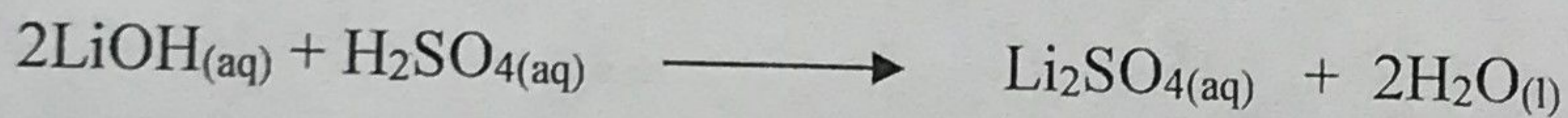
$$\therefore \% \text{ yield} = \frac{15 \text{ g}}{24.323} \times 100\% = 62\%$$

7. Examine the solubility curve shown below and answer the following questions:

- a) What term best describes a solution that contains 80 g of KNO_3 at 30°C ? Supersaturated (1 mark)
- b) Which substance is least soluble at 25°C ? $\text{Ce}_2(\text{SO}_3)_3$ (1 mark)
- c) At what temperature is the solubility of KClO_3 equal to $40\text{g}/100\text{g}$ of water? $\sim 87^\circ\text{C}$ (1 mark)
- d) How much KNO_3 will precipitate out of solution if a saturated solution is cooled from 40°C to 20°C ? $\sim 30\text{g}$ (1 mark)



8. A 30.5 mL of a 1.2 mol/L LiOH solution was mixed with a 15.1 mL of a 1.1 mol/L H_2SO_4 solution.



- a) Which reactant is the **limiting** reagent/reactant (2 marks)

$$\frac{0.0305\text{L} / 1.2\text{mol LiOH} / 1\text{mol Li}_2\text{SO}_4}{2\text{mol LiOH}} = 0.0183\text{mol Li}_2\text{SO}_4$$

$$\frac{0.0151\text{L} / 1.1\text{mol H}_2\text{SO}_4 / 1\text{mol Li}_2\text{SO}_4}{1\text{mol H}_2\text{SO}_4} = 0.0166\text{mol Li}_2\text{SO}_4$$

L.R. (H_2SO_4)

ANS: _____

- b) What is the **pH** of the final solution (3 marks)

$$\frac{0.0151\text{L} / 1.1\text{mol H}_2\text{SO}_4 / 2\text{mol LiOH}}{1\text{mol H}_2\text{SO}_4} = 0.0332\text{mol LiOH used}$$

$$\frac{0.0305\text{L} / 1.2\text{mol LiOH}}{1} = 0.0366\text{mol initial} \quad \therefore 0.0366 - 0.0332 = 3.38 \times 10^{-3}\text{mol left}$$

$$\text{Then } [\text{OH}^-] = \frac{3.38 \times 10^{-3}\text{mol}}{0.0456\text{L}} = 0.074\text{M}$$

$$\text{Then } \text{pOH} = -\log[\text{OH}^-] = -\log(0.074) = 1.13$$

$$\therefore \text{pH} = 14 - \text{pOH} = 14 - 1.13 = \boxed{12.87}$$

ANS: _____

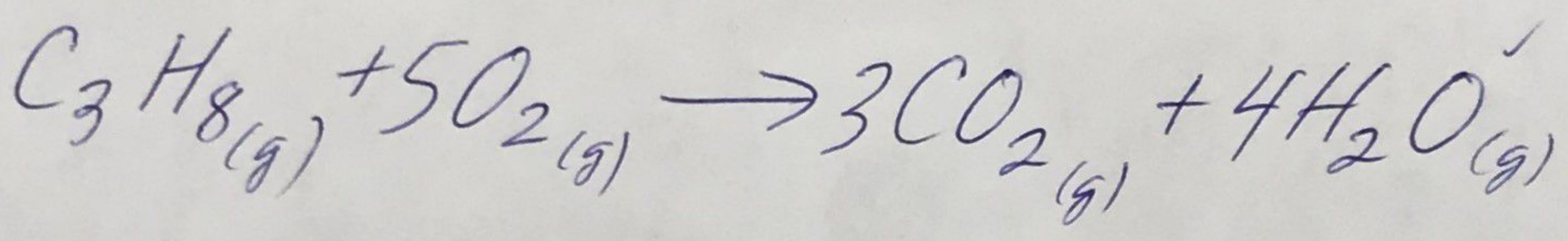
9. A mountaineer is at the base of Mt. Logan, where the temperature is 15 °C and pressure 101 kPa. An inflated balloon is brought to the top of the mountain, where the temperature is -28 °C. The mountaineer observes the balloon at the top of the mountain has become 90% of its original volume. What is the **pressure** at the top of the mountain? Assume a closed system with no gas entering or escaping the balloon. (_____ / 3 marks)

$$\frac{101 \text{ kPa} \quad | \quad 245 \text{ K} \quad | \quad 14}{288 \text{ K} \quad | \quad 0.9 \text{ V}}$$

$$= \boxed{95.5 \text{ kPa}}$$

ANS: _____

10. Calculate the volume of oxygen required to burn 50 dm³ of propane gas, C₃H₈, to carbon dioxide and steam, all four gases being measured at 110°C and 104 kPa pressure. (_____ / 3 marks)



$$\frac{50 \text{ dm}^3 \text{ C}_3\text{H}_8 \quad | \quad 5 \text{ dm}^3 \text{ O}_2}{1 \text{ dm}^3 \text{ C}_3\text{H}_8}$$

$$= \boxed{250 \text{ dm}^3 \text{ O}_2}$$

ANS: _____