Question 1:

a- For the following substances, state whether they are most likely a pure substance, a heterogeneous mixture or homogeneous mixture.

1- Tap water  
   Homogeneous Mix.

2- Beach sand  
   Heterogeneous Mix.

3- Copper wire  
   Pure substance

b- Indicate whether the following represent physical or chemical changes.

1- Burning gasoline in your car engine.  chemical change

2- The heating of water to produce steam.  Physical change

3- Making wine.  Chemical change

c- Give the names of two different methods which can be used to separate the components of a mixture from one another.

Filtration
Distillation
Chromatography

d- Give two examples for extensive and two examples for intensive properties.

Density, boiling point
Mass, Volume
Question 2:

a- Convert $-40 \, ^{\circ}\text{F}$ to $^{\circ}\text{C}$ and Kelvin temperature.

$$T_F = 1.8 \, T_C + 32$$

$$T_C = \frac{-40 - 32}{1.8} = -40 ^{\circ}\text{C}$$

$$T_K = T_C + 273 = 233 \, K$$

b- A certain petroleum reserve contains $9.6 \times 10^9$ barrels. What is the amount of petroleum in liters?

1 barrel = 42 gal
1 gal = 4 qt
1 qt = 57.75 in$^3$
1 in = 2.54 cm

$$9.6 \times 10^9 \text{ barrel} \times \frac{42 \text{ gal}}{1 \text{ barrel}} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{57.75 \text{ in}^3}{1 \text{ qt}} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{10^3 \text{ cm}^3}{1 \text{ in}^3} = 1526.3 \times 10^9 \text{ liters}$$
Question 3:

a- Write the formulae of the following compounds.
   i- Ammonium Sulfate \((\text{NH}_4)_2\text{SO}_4\)
   ii- Dichlorine heptoxide \(\text{Cl}_2\text{O}_7\)
   iii- Chloric acid \(\text{HClO}_3\)
   iv- Tetraphosphorous decaoxide \(\text{P}_4\text{O}_{10}\)

b- Write the names of the following compounds.
   i- \(\text{NCl}_3\) Nitrogen trichloride
   ii- \(\text{H}_3\text{PO}_4\) Hydrogen phosphate
   iii- \(\text{MgBr}_2\) Magnesium bromide
   iv- \(\text{Fe(NO}_3)_2\) Iron(II) Nitrate

c- Write a nuclear equation for each of the following.
   i- Radium-226 emitting an \(\alpha\) particle (symbol of Radium is Ra)

   \[
   {}_{88}^{226}\text{Ra} \rightarrow {}_{2}^{4}\text{He} + {}_{86}^{222}\text{Rn}
   \]

   ii- Technetium (Tc)-98 emitting a \(\beta\) particle.

   \[
   {}_{43}^{99}\text{Tc} \rightarrow {}_{-1}^{0}\text{e} + {}_{44}^{99}\text{Ru}
   \]
Question 4:

HMD is a compound used in the production of nylon. It has the molecular formula, C₆H₁₄N₂ and molar mass 116.2 g/mol.

Calculate, in 3.011 x 10²³ molecules of C₆H₁₄N₂:

a- Mass of C₆H₁₄N₂

b- Number of moles of C₆H₁₄N₂

c- Mass of N-atoms

d- Number of N-atoms

\[ \text{a- } 6.022 \times 10^{23} \text{ molecules } \frac{116.2 \text{ g}}{1} = 58.1 \text{ g} \]

\[ \text{b- } \frac{\text{58.1 g}}{116.2 \text{ g/mol}} = 0.5 \text{ mol} \]

\[ \text{c- } 0.5 \text{ mol } \text{C}_6\text{H}_{14}\text{N}_2 \text{ 1 mol } \text{N exist} \]

\[ 1 \text{ mol N} = 14.01 \text{ g} \]

\[ \text{d- } 1 \text{ mol N atom } = 6.022 \times 10^{23} \text{ N atom} \]
Question 5:

Heptanol has the formula \( C_7H_{16}O(l) \) and can be combusted (burned) in the presence of oxygen to produce carbon dioxide and water vapor.

a- Write a balanced equation for the reaction.

\[
2C_7H_{16}O(l) + 21O_2(g) \rightarrow 14CO_2(g) + 16H_2O(g)
\]

b- If 15.0 g of heptanol is combusted in the presence of 23.0 g of \( O_2 \), how many grams of water will be produced?

(What is the theoretical yield of water?)

\[
\begin{align*}
15.0 \text{ g} & \quad \frac{1 \text{ mol C}_7\text{H}_{16}O}{116.198 \text{ g C}_7\text{H}_{16}O} \quad \frac{16 \text{ mol H}_2O}{2 \text{ mol C}_7\text{H}_{16}O} \quad \frac{18.016 \text{ g H}_2O}{1 \text{ mol H}_2O} \\
& = 18.6 \text{ g H}_2O
\end{align*}
\]

\[
\begin{align*}
23.0 \text{ g} O_2 & \quad \frac{1 \text{ mol O}_2}{32 \text{ g O}_2} \quad \frac{16 \text{ mol H}_2O}{21 \text{ mol O}_2} \quad \frac{18.016 \text{ g H}_2O}{1 \text{ mol H}_2O} \\
& = 9.87 \text{ g H}_2O
\end{align*}
\]

So 9.87 g \( H_2O \) will be produced.

c- What is the limiting reactant?

\( O_2 \) is the limiting reactant
Question 6:

A sample of 56 mg Ne gas in a given container, initially at 0.600 atm pressure and at 500 K, has its volume doubled and its temperature tripled. In the final state, calculate:

a- The pressure exerted by the gas.

b- How much faster Ne atoms would move in the final state than in the initial state? (in other words, calculate \( u_2/u_1 \))

\[ \text{INITIAL STATE} \quad \text{FINAL STATE} \]

\[ m_{\text{Ne}} = 56 \text{ mg} \quad m_{\text{Ne}} = 56 \text{ mg} \]

\[ P_1 = 0.600 \text{ atm} \quad P_2 = ? \]

\[ T = 500 \text{ K} \quad T = 1500 \text{ K} \]

\[ V \]

\[ P_1 \cdot V = n \cdot R \cdot T \quad \frac{P_1}{P_2} = \frac{2}{3} \quad \frac{P_2}{3} = \frac{500}{3} \]

\[ P_2 = 0.9 \text{ atm} \]

\[ 2V = n \cdot R \cdot 3T \]

b) \[ \frac{u_2}{u_1} = \left( \frac{T_2}{T_1} \right)^{1/2} \quad \frac{u_2}{u_1} = \left( \frac{3 \cdot 1500}{500} \right)^{1/2} \quad \frac{u_2}{u_1} = 1.73 \]

\[ u_2 = 1.73 \ u_1 \]

At 1500 K Ne atoms move 1.7 times faster than at 500 K.
Question 7:

Hexane $C_6H_{14}$ is the main ingredient of the fuel used in automobiles. It has a density of 0.654g/ml. Calculate the volume of air (21% $O_2$ by volume) required at 25°C and 1 atm to burn one liter of hexane.

*Hint:* First you have to write a balanced chemical equation.

$$2C_6H_{14}(g) + 19O_2(g) \rightarrow 12CO_2(g) + 14H_2O(g)$$

1 liter $C_6H_{14}$ at $\frac{654g}{1\text{ liter}} = 654g$ $C_6H_{14}$

654g $C_6H_{14}$ $\frac{1\text{ mol} C_6H_{14}}{86.172g} = 7.59\text{ mol} C_6H_{14}$

7.59 mol $C_6H_{14}$ $\frac{19\text{ mol} O_2}{2\text{ mol} C_6H_{14}} = 72.105\text{ mol} O_2$

$$V_{O_2} = \frac{NRT}{P} = \frac{72.105\text{ mol} \times 0.0821\frac{\text{ L atm}}{\text{ mol K}} \times 298\text{ K}}{1\text{ atm}}$$

$$V_{O_2} = 1764.1\text{ L}$$

100% air $\rightarrow$ 21% $O_2$

$1764.1\text{ L} O_2$

$$V_{air} = \frac{1764.1\text{ L} \times 100}{21} = 8405.2\text{ L air}$$