1. Methanol undergoes complete combustion in the presence of atmospheric oxygen at SLC.
   a. Write a balanced thermochemical reaction for the complete combustion of methanol at SLC.

      Step 1 write a balanced chemical
      $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$
      step 2 Look up the molar heat of combustion of methanol from data book (726 kj?mol)

      Step 3 calculate the for equation $\Delta H = -2 \times 726$ kJ/mol

      Step 4 write the balanced thermochemical equation
      $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O \; \Delta H = -1452$ kJ/mol

   b. What volume of oxygen gas is used when 2.45 MJ of energy is released?

      Step 1 Convert energy to kJ => 2.45×10^3kJ
      Step 2 Apply the ratio as per equation
      => (1452 / 3) = (2450/x) where x is the number of mol, of oxygen gas used.

      Step 3 Solve for x
      => (2450/1452) X 3 = 5.061 mol

      Step 4 Find the volume.
      => Easy way => 5.061 X 24.8 L = 126L (3 sig figs)
      => Involved way => PV=nRT => V = nRT/P = 5.061 X 8.31 X 298 /100 = 126L (3 sig figs)

   c. On an industrial scale, methanol is predominantly produced from natural gas by reforming the gas with steam and then processing the resulting synthesized gas mixture to create pure methanol. Describe the conditions, under which methanol is formed, that would enable it to be labelled as a renewable fuel.
      Where the methane gas is sourced form renewable sources such as decomposition of organic matter.

2. Consider the three molecules shown on the right.

   Identify the following statements as True or False. Explain your choice.

$C_4H_{10}O_2$	Methyl butanoate
C_7H_{16}	Heptane
$CH_3(CH_2)_{12}CH_3$	Tetradecane

   i. Methyl butanoate and heptane have molar masses that are very similar. Methyl butanoate, however, would be expected to have a higher cloud and flash point than heptane.
      True. The strength of intermolecular bonding dictates the cloud and flash points. The stronger the intermolecular bonding the higher the cloud and flash points of fuels. Intermolecular forces (van der waals) found in methyl butanoate consist of dipole-dipole and dispersion forces. These are significantly stronger than the intermolecular forces in heptane which consisnt solely of dispersion forces.
   ii. Tetradecane should be more viscous than heptane and methyl butanoate.
      True. This can be argued by referring to the size of the molecule. Tetradecane is substantially large than both heptane and methyl butanoate and as such has significantly stronger intermolecular forces due to dispersion forces. Even

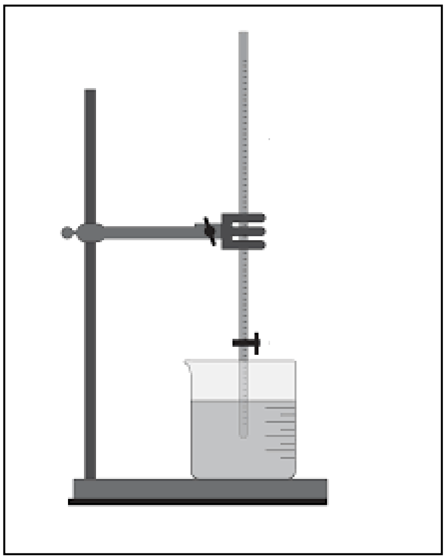
though methyl butanoate has dipole-dipole it can be argued that the significant difference in size gives tetradecane much greater dispersion forces that increase the intermolecular forces of attraction beyond those found in the smaller molecuels.

iii. Methyl butanoate and tetradecane are produced via a condensation reaction.

False. Only the ester, methyl butanoate, is formed via a condensation reaction (esterification reaction) while heptane is simply purified from crude oil.

iv. Methyl butanoate is a net zero carbon emitter as the molecules it is made from are both produced via photosynthesis and fermentation reactions.
False. Photosynthesis ($6CO_2(g) + H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$ is not involved in the production of methanol nor butanoic acid which are reactants in the production of methyl butanoate nor is fermentation ($C_6H_{12}O_6(aq) \rightarrow CO_2(g) + 2CH_3CH_2OH(aq)$)

3. The calculate enthalpy change for the dissolving of anhydrous copper sulfate as shown below.
$CuSO_4(s) \rightarrow Cu^{2+}(aq) + SO_4^{2-}(aq)$ $\Delta H = ?$



A given amount of anhydrous copper sulfate is dissolved in a beaker of water. The temperature of the water is monitored using a hand-held thermometer, as shown on the right.
The procedure for the investigation is summed up below.
A 100mL beaker is placed on a elecronic balance and weighed. Water is added to fill the beaker to the 100ml mark and once again the mass of the beaker and water recorded. Finally, a sample of $CUSO_4$ is added to the beaker of water and the final mass of water, beaker and $CuSO_4$ is recorded. The initial temperature of the eater in the beaker is recorded. The temperature of the water is allowed to reach its maximum where it is finally recored.
Below is a table of data collected from the investigation.

Measurement	Value
Mass of empty 100ml beaker	50.55 grams
Mass of 100ml beaker and water	145.56 grams
Mass 100ml beaker with water and sample of $CuSO_4$	150.56 grams
Initial temperature of water	23.00 °C
Final temperature of water	33.00 °C

a. Calculate the mol of $cuSO_4$ (molar mass 159.6 g/mol) dissolved in the water
=> (mass of $CUSO_4$) / molar mass of $CuSO_4$ => 5.00 / 159.6 => 3.13×10^{-2} mol

b. Calculate the amount of energy, in kJ, released when one mole of anhydrous $CuSO_4$ dissolves in water.

Step 1 – Find the difference in temperature $\Delta T = 10.00^{o}c$

Step 2 – Calculate the amount of energy released

=> E(J) = c X m X ΔT = 4.18 X (145.56 – 50.55) X 10.00 = 3971 J = 3.97 kJ

Step 3 – Find the energy released per mol of $CuSO_4$

=> 3.97 kJ / 3.12 X 10^{-2} = 127 kJ

c. Below is a table of data that another grouprecorded of the temperature of the water every minute for 7 minutes. This group used an identical mass of $CuSO_4$.

i. Graph the results on the graph paper below and use the graph to obtain a more accurate value for the energy (kJ) released per mole of $CuSO_4$ dissolved.

ii. Discuss why this is a more accurate representation of the energy per mol.

Time(min)	Temperature °C
0	23.00
1	26.00
2	29.00
3	33.00
4	32.00
5	29.00
6	26.00
7	23.00

E(J) = c X m X ΔT = 4.18 X (145.56 – 50.55) X 22.00 = 8737 J = 8.737 kJ

=> energy / mol = 8.737 / 0.0313 = 279 kJ/mol

This is more accurate as it takes into account the energy loss from the beaker of water as the temperature is rising. Extrapolating back to the Y-axis gives a better indication of the temperature difference than just taking the highest value of temperature of the water.