#3

Key

SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

1. Methanol is made in large quantities as it is used in the production of polymers and in fuels. The enthalpy of combustion of methanol can be determined theoretically or experimentally.

$$*\ CH_3OH(l) + 1\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

	$CH_3OH(l)$	$O_2(g)$	$CO_2(g)$	$H_2O(g)$
Standard enthalpy of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}	-239	0	-394	-242
HL Entropy, $S^{\ominus}$ / J K^{-1} mol^{-1}	240	205	214	189

(a) Using the information from the table above, determine the theoretical enthalpy of *combustion of methanol. [2]

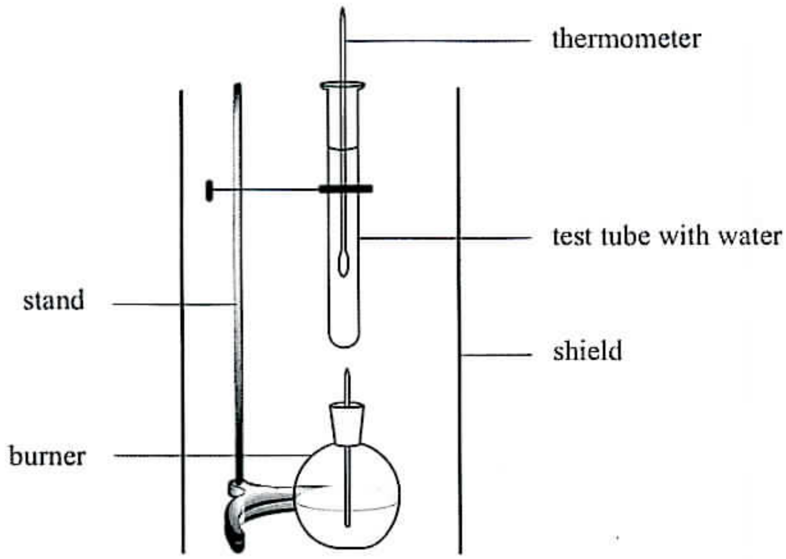
$$\Delta H_c = [(-394) + 2(-242)] - [(-239) + (0)]$$

$$= \boxed{-639\ \text{kJ mol}^{-1}}$$

(This question continues on the following page)

(Question 1 continued)

(b) The enthalpy of combustion of methanol can also be determined experimentally in a school laboratory. A burner containing methanol was weighed and used to heat water in a test tube as illustrated below.



The following data were collected.

Initial mass of burner and methanol / g	80.557
Final mass of burner and methanol / g	80.034
Mass of water in test tube / g	20.000
Initial temperature of water / °C	21.5
Final temperature of water / °C	26.4

(i) Calculate the amount, in mol, of methanol burned. *[2]*

$80.557 - 80.034 = 0.523\,g\ CH_3OH$

$n = \frac{0.523g}{32.05g/mol} = \boxed{0.0163\,mol}$

(Question 1 continued) $\Delta T = T_f - T_i$!

(ii) Calculate the heat absorbed, in kJ, by the water. *[3]*

$\Delta T = 26.4 - 21.5 = 4.9\ °C$

$q = (20.000\,g)(4.18\,J/g°C)(4.9°C) = 410\,J$

$= \boxed{0.41\,kJ}$

(iii) Determine the enthalpy change, in kJ mol^{-1}, for the combustion of methanol. *[2]*

$\Delta H = \frac{-0.41\,kJ}{0.0163\,mol} = \boxed{-25\,kJ\,mol^{-1}}$

(c) The Data Booklet value for the enthalpy of combustion of methanol is –726 kJ mol^{-1}. Suggest why this value differs from the values calculated in parts (a) and (b).

(i) Part (a) *[1]*

Reaction did not take place at standard conditions. (Assumed by the $\Delta H°$ values used)

(ii) Part (b) *[1]*

Not all heat was transfered to the water, some was lost to the surroundings.

0532

HL

(d) Determine the $\Delta S^{\ominus}$ for the combustion of methanol. [2]

$$CH_3OH\,(l) + 1\tfrac{1}{2}O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(g)$$

$$\Delta S = [(214) + 2(189)] - [(240) + (1.5)(205)]$$

$$= \boxed{44.5\ J\,K^{-1}\,mol^{-1}}$$

= - 726 kJ mol^{-1}

HL

(e) Using the enthalpy of combustion for methanol from Table 12 of the Data Booklet and the $\Delta S^{\ominus}$ determined in part (d), calculate the standard free energy change for the combustion of methanol. [3]

$$\Delta G = (-726\ kJ/mol) - (298\ K)(0.0445\ kJ/mol\,K)$$

$$= \boxed{-739\ kJ\,mol^{-1}}$$

HL

(f) Explain whether changing the temperature will alter the spontaneity of the reaction. [1]

ΔG will always be negative regardless of temperature, therefore the reaction will always be spontaneous.