Unit 4 · Chemical Thermodynamics

WORKSHEET

Full marks 33

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 33

1 Key words [4]

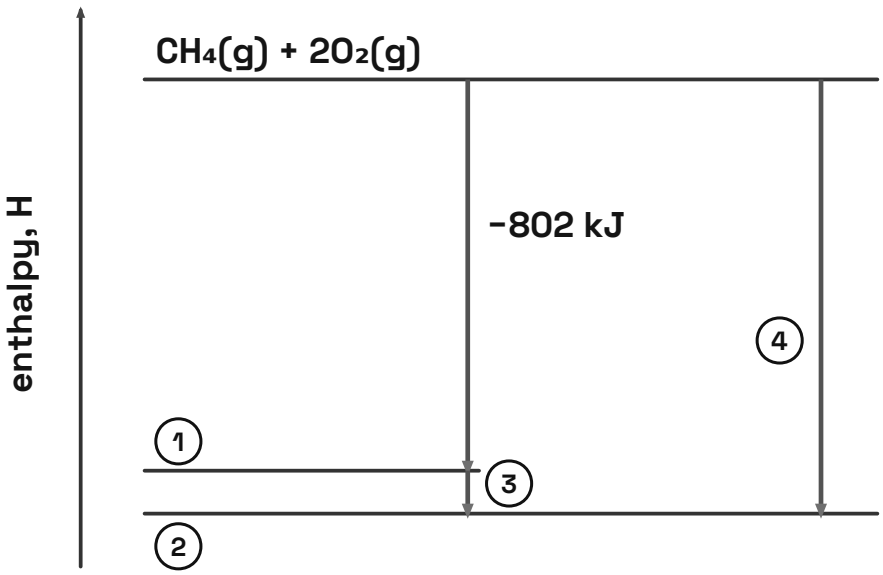
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

endothermic	**enthalpy**	**entropy**	**extensive**	**Gibbs free energy**	**intensive**	**isolated**
path function	**spontaneous**	**state function**				

A system that can exchange neither matter nor energy with its surroundings is an _____ system. A property such as temperature or density, which does not depend on the amount of matter, is an _____ property. A quantity that depends only on the state of a system, not on how it got there, is a _____. The heat absorbed at constant pressure is the change in _____, and a reaction that absorbs heat is _____. The measure of the disorder of a system is its _____. A process that goes on by itself once started is _____; at constant temperature and pressure it has a negative change in _____.

2 Label the diagram [2]

The enthalpy diagram shows methane burning, by two routes. Write what belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. Which of these is a state function? [1]

a. heat **b.** work

c. enthalpy **d.** heat and work both

ii. A gas absorbs 250 J of heat, and 400 J of work is done on it as it is compressed. The change in its internal energy is: [1]

a. −150 J **b.** +150 J

c. +650 J **d.** −650 J

iii. For which reaction is ΔH equal to ΔE? [1]

a. $N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g)$ **b.** $C(s) + O_2(g) \rightarrow CO_2(g)$

c. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ **d.** $2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(l)$

iv. In which change does the entropy of the system increase? [1]

a. water freezing **b.** steam condensing

c. ice melting **d.** $N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g)$

v. A reaction has ΔH negative and ΔS positive. It is: [1]

a. spontaneous at every temperature **b.** spontaneous only at high temperatures

c. spontaneous only at low temperatures **d.** never spontaneous

4 Short answers [7]

Write short answers to the following questions.

a. State Hess's law of constant heat summation. Write one use of it. [2]

b. Distinguish a spontaneous process from a non-spontaneous one, with one example of each. [2]

c. Use the average bond enthalpies (kJ/mol) C=C 612, Cl–Cl 239, C–C 347, C–Cl 339 to estimate ΔH for the addition of chlorine to ethene: $CH_2{=}CH_2(g) + Cl_2(g) \rightarrow CH_2ClCH_2Cl(g)$. Is the reaction exothermic or endothermic? (The four C–H bonds are not broken.) [3]

5 Long answer [4]

Write a long answer to the following question.

What is Gibbs free energy? Write the equation that links ΔG with ΔH and ΔS, and use it to say how a reaction whose ΔH and ΔS are both positive behaves at low and at high temperatures. What does $\Delta G = 0$ mean?

6 Numerical problems [8]

Solve the following problems. Show your working. Take $\Delta H°f$ (kJ/mol): $C_2H_4(g)$ +52.4, $CO_2(g)$ −393.5, $H_2O(l)$ −285.8; $R = 8.314$ J mol^{-1} K^{-1}; C = 12, H = 1.

a. Ethene burns completely in oxygen: $C_2H_4(g) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 2\,H_2O(l)$ [4]

i. Find its standard enthalpy of combustion from the enthalpies of formation.

ii. Find ΔE for the reaction at 298 K.

iii. Find the calorific value of ethene in kJ/g.

iv. What mass of ethene must burn to give 1000 kJ of heat?

Answer:

b. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $\Delta H^\circ = +57.2$ kJ/mol and $\Delta S^\circ = +175.8$ J mol^{-1} K^{-1}. **[4]**

i. Find ΔG° at 298 K. Is the reaction spontaneous there?

ii. Above what temperature does it become spontaneous?

iii. Find its equilibrium constant at 298 K.

iv. Find ΔG° at 400 K.

Answer: _____

7 Think **[3]**

When ammonium nitrate dissolves in water, the solution becomes so cold that the outside of the beaker is wet with dew; cold packs for sports injuries work this way. Heat is absorbed, yet the salt dissolves by itself. How can an endothermic process be spontaneous?

8 Activity: Warm or cold when it dissolves? (not marked)

In the laboratory, with goggles and gloves on, stir one spatula-full of each solid into 20 mL of water at room temperature in a test tube, and read a thermometer before and after: ammonium chloride, urea, anhydrous calcium chloride, and two pellets of sodium hydroxide (corrosive: never touch them).

Substance	Temperature before (°C)	Temperature after (°C)	Exothermic or endothermic?
Ammonium chloride			
Urea			
Calcium chloride (anhydrous)			
Sodium hydroxide			

Which would you put in a cold pack, and which in a self-heating pack? The endothermic ones dissolved by themselves: what must have increased?