

TEST: Entropy and Free Energy

Multiple Choice (14 marks)

(Total = 44)

1. The reaction which represents the **greatest increase in entropy** is ...

- A. $X_2(s) + Y_2(g) \rightarrow 2XY(g)$
- B. $M(s) + O(s) \rightarrow MO(s)$
- C. $X(g) \rightarrow X(l)$
- D. $X_2(g) + Y_2(g) \rightarrow 2XY(g)$

2. The spontaneous evaporation of methanol(CH_3OH) is **evidence of** ...

- A. a natural tendency towards minimum potential energy
- B. a natural tendency towards increasing randomness
- C. the existence of a state of equilibrium
- D. a high activation energy

3. Which of the following combinations of enthalpy and entropy changes would **always give a spontaneous reaction**?

- | | Enthalpy | Entropy |
|----|-----------------|----------------|
| A. | increased | increased |
| B. | increased | decreased |
| C. | decreased | decreased |
| D. | decreased | increased |

4. A **decrease in entropy** occurs when ...

- A. a solid sublimates to a gas
- B. hydrogen gas and oxygen gas combine to form water molecules
- C. sugar dissolves in water
- D. coal burns to carbon dioxide gas and water vapour

5. A reaction is **most** likely to be spontaneous if ...

- A. the reaction is endothermic and has a high activation energy
- B. the reaction is endothermic and has a low activation energy
- C. the reaction is exothermic and has a high activation energy
- D. the reaction is exothermic and has a low activation energy

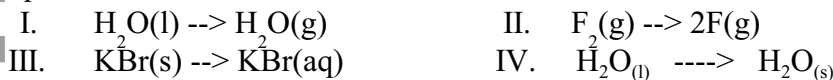
6. When the substances $H_2(g), O_2(g), H_2O(l)$ are arranged in order of **increasing entropy** values at $25^\circ C$, what is the correct order?

- A. $H_2(g), O_2(g), H_2O(l)$
- B. $H_2(g), H_2O(l), O_2(g)$
- C. $O_2(g), H_2(g), H_2O(l)$
- D. $H_2O(l), H_2(g), O_2(g)$

7. What is true about the signs of ΔH and ΔS for a reaction that is spontaneous at low temperatures but becomes non-spontaneous at higher temperatures?

	ΔH	ΔS
A.	-	-
B.	-	+
C.	+	+
D.	+	-

8. For which of the following processes, carried out at 25°C, is the value of ΔS positive?



- A. I, II and III B. I, II and IV C. IV only D. III only

9. Which one of the following processes would be expected to have a value of ΔS° closest to zero?



10. The entropy change when a **liquid is vapourized** may be represented as ...

- A. $\Delta S = 0$ B. $\Delta S > 0$ C. $\Delta S < 0$ D. $\Delta H < 0$

11. The signs of ΔH and ΔS for the process, $\text{I}_2\text{(s)} \rightarrow \text{I}_2\text{(g)}$ are **respectively** ...

- A. positive and positive and the reaction is endothermic
 B. positive and positive and the reaction is exothermic
 C. positive and negative and the reaction is exothermic
 D. positive and negative and the reaction is endothermic

12. The ΔH for a reaction is 77 kJ/mol and the ΔS for the reaction is 22 kJ/mol.K. **The temperature at which the reaction becomes spontaneous is ...**

- A. 3.5 K B. 3.5×10^3 K C. 55 K D. 1.7×10^3 K

13. Given that the normal freezing point of ammonia is -78 °C. Predict the signs of ΔH , ΔS , and ΔG for ammonia when it freezes at -80 °C and 101.3 kPa.

	ΔH	ΔS	ΔG
A.	-	-	-
B.	-	-	0
C.	+	+	0
D.	+	-	+

14. If it is necessary to employ an electric current continuously in order for a reaction to take place, which one of the following must always be true for that reaction?

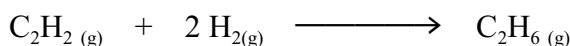
- A. $\Delta H > 0$ B. $\Delta H < 0$ C. $\Delta G > 0$ D. $\Delta G < 0$

PROBLEMS (30marks)

1. A particular reaction has $\Delta H < 0$ and $\Delta S > 0$. At what temperatures will the reaction be spontaneous? Explain /3

2. Under what circumstances is it possible for an endothermic process to proceed spontaneously? Explain. /3

3. Consider the reaction ...



Information about the substances ...

Substance	ΔH_f° (KJ/mol)	S° (J/mol.K)
$\text{C}_2\text{H}_2(\text{g})$	226.7	200.9
$\text{H}_2(\text{g})$	0	130.7
$\text{C}_2\text{H}_6(\text{g})$	- 84.7	-----

a) Define the terms: ΔH_f° , ΔS° , ΔG_f° . Be precise. /3

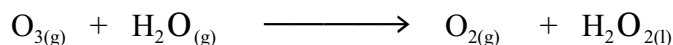
b) Explain the significance of the signs of the values for each of the above terms. /3

c) Determine the standard enthalpy for the above reaction. /3

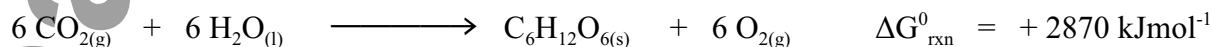
d) If the value for the standard entropy change for the reaction, $\Delta S_{\text{rxn}}^\circ$, is - 232.7 J/mol.K, calculate the standard molar entropy, S° , of $\text{C}_2\text{H}_6(\text{g})$. /3

e) Calculate the value of the standard free-energy change for the reaction, $\Delta G_{\text{rxn}}^\circ$. What does the sign of ΔG° indicate about the reaction above? /4

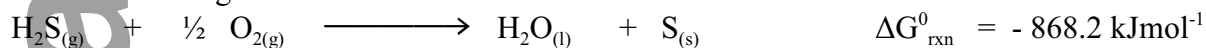
4. In a court case, a woman sued a chemical company for damages. She claimed the company produced ozone, O_3 , which reacted with the water in the air to produce hydrogen peroxide. The hydrogen peroxide in turn bleached her beautiful black hair to a devilish red. You are her lawyer. Is the following reaction thermodynamically feasible? Is it spontaneous under standard conditions? Is her claim valid, should she be awarded damages? (5)



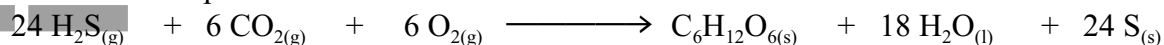
5. Photosynthetic bacteria carry out the synthesis of high free energy compounds such as glucose from CO_2 and H_2O using light as the source of energy ...



However, in the deep ocean where there is no light, this same synthesis can apparently be done by bacteria using hydrogen sulphide as the energy source. **Show that**, by adding the following reaction ...



to the glucose synthesis reaction above, sufficient free energy will be produced so that the overall process ...



is spontaneous.

(3)