



**MAASAI MARA UNIVERSITY**  
**REGULAR UNIVERSITY EXAMINATIONS**  
**2020/2021 ACADEMIC YEAR**  
**THIRD YEAR FIRST SEMESTER**  
**SCHOOL OF PURE APPLIED AND HEALTH SCIENCES**  
**BACHELOR OF SCIENCE IN CHEMISTRY**

**COURSE CODE: CHE 3121**

**COURSE TITLE: CHEMICAL THERMODYNAMICS AND  
PHASE EQUILIBRIA**

**DATE: 7 TH APRIL, 2022**

**TIME: 1100-1300HRS**

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**INSTRUCTIONS TO CANDIDATES**

1. Answer Question **ONE** and any other **TWO** questions.
2. All Examination Rules Apply.

### QUESTION ONE (30MKS)

- a) Define the triple point and state its significance (2mks)
- b) Explain one property that affects vapour pressure (2mks)
- c) Describe and give one example of a metastable phases (3mks)
- d) Calculate the change in entropy when 25kJ of energy is transferred reversibly and isothermally as heat to a large block of iron at 100° C (3mks)
- e) Describe a phase transition (2mks)
- f) Sketch a phase diagram and illustrating the regions of various phases (4mks)
- g) Calculate the standard reaction enthalpy and the change in standard Gibbs energy for the combustion of methane which follows the reaction  $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$   
 $\Delta_f H^\ominus (\text{CH}_4(\text{g})) = -74.81 \text{kJmol}^{-1}$ ,  
 $\Delta_f H^\ominus (\text{O}_2(\text{g})) = 0 \text{kJmol}^{-1}$   
 $\Delta_f H^\ominus (\text{CO}_2(\text{g})) = -393.51 \text{kJmol}^{-1}$   
 $\Delta_f H^\ominus (\text{H}_2\text{O}(\text{g})) = -285.83 \text{kJmol}^{-1}$   
 $\Delta_r S^\ominus = -243 \text{JK}^{-1}$  (6mks)
- h) For an adiabatic change,  $\Delta S_{\text{sur}} = 0$ . Explain. (3mks)
- i) Calculate the entropy change in the surroundings for an isothermal reversible change at constant pressure when 1.00 mol  $\text{H}_2\text{O}(\text{l})$  is formed from its elements under standard conditions at 298 K given that  $\Delta H^\ominus = -290 \text{kJ}$ . (3mks)
- j) State two distinctions between normal boiling point and standard boiling point. (2mks)

### QUESTION TWO (20MKS)

- a) Calculate the entropy change in the system when 1.00 mol of  $\text{N}_2\text{O}_4(\text{g})$  is formed from 2.00 mol  $\text{NO}_2(\text{g})$  under standard conditions at 298 K given that the enthalpy change for the reaction is  $57.20 \text{kJ mol}^{-1}$  (3mks)
- b) Calculate the molar entropy of a constant-volume sample of argon at 250 K given that it is  $154.84 \text{J K}^{-1} \text{mol}^{-1}$  at 298 K. ( $C_v = 20.786$ ) (3mks)
- c) Calculate  $\Delta S$  (for the system) when the state of 2.00 mol diatomic perfect gas molecules, for which  $C_{p,m} = 7/2R$ , is changed from 25°C and 1.50 atm to 135°C and 7.00 atm. How do you rationalize the sign of  $\Delta S$ . (6mks)
- d) Calculate the standard reaction Gibbs energy of the reaction  $\text{Hg}(\text{l}) + \text{Cl}_2(\text{g}) \rightarrow \text{HgCl}_2(\text{s})$  given;  $\Delta_f G^\ominus (\text{Hg}(\text{l})) = 0 \text{KJmol}^{-1}$   $\Delta_f G^\ominus (\text{Cl}_2(\text{g})) = 0 \text{KJmol}^{-1}$ ,  $\Delta_f G^\ominus (\text{HgCl}_2(\text{s})) = -178.60 \text{KJmol}^{-1}$ . (2mks)

e) Suppose that for a certain phase transition of a solid,  $\Delta_{\text{trs}}V = +1.0 \text{ cm}^3 \text{ mol}^{-1}$  which is dependent on pressure and an increase in pressure to 3.0 Mbar ( $3.0 \times 10^{11} \text{ Pa}$ ) from 1.0 bar ( $1.0 \times 10^5 \text{ Pa}$ ) occurs. Calculate the change in Gibb's energy for the transition if the transition temperature is 300K.

**(3mks)**

f) A phase transition is accompanied by change in entropy. Explain. **(3mks)**

### QUESTION THREE (20mks)

a) Define and explain the formation of a supercritical fluid **(4mks)**

b) Predict the enthalpy of vaporizations of ethane and bromine molecules from their boiling points of  $-88.6 \text{ }^\circ\text{C}$ . and  $59.2 \text{ }^\circ\text{C}$  respectively. Given that they follow the Trouton rule. **(4mks)**

c) Explain why water and methane deviate from the Trouton rule. **(4mks)**

d) Calculate the standard Gibbs energy of the reaction  $\text{CH}_3\text{OH}(\text{l}) + \text{CO}(\text{g}) \rightarrow \text{CH}_3\text{COOH}(\text{l})$  at 298K given;  $\Delta_f H^\theta (\text{CH}_3\text{OH}(\text{l})) = -238.66 \text{ KJmol}^{-1}$ ,  $\Delta_f H^\theta (\text{CO}(\text{g})) = -393.51 \text{ KJmol}^{-1}$ ,  $\Delta_f H^\theta (\text{CH}_3\text{COOH}(\text{l})) = -484.5 \text{ KJmol}^{-1}$ ,  $\Delta_f S^\theta (\text{CH}_3\text{OH}(\text{l})) = 126.8 \text{ Jmol}^{-1}\text{K}^{-1}$ ,  $\Delta_f S^\theta (\text{CO}(\text{g})) = 213.74 \text{ Jmol}^{-1}\text{K}^{-1}$ ,  $\Delta_f S^\theta (\text{CH}_3\text{COOH}(\text{l})) = 159.8 \text{ Jmol}^{-1}\text{K}^{-1}$  **(5mks)**

e) Explain with an example what is meant by a state function. **(2mks)**

### QUESTION FOUR (20mks)

a) Estimate the change in Gibbs energy of  $1\text{dm}^{-3}$  of benzene when the pressure acting on it is increased from 1atm to 100atm **(3mks)**

a) Calculate the standard reaction entropy of the reaction:  $\text{CH}_3\text{CHO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CH}_3\text{COOH}(\text{l})$  at  $25^\circ\text{C}$  and state the significance of the entropy value given:  $\Delta_f S_m^\theta (\text{CH}_3\text{CHO}(\text{g})) = 250.3 \text{ J K}^{-1}$ ,  $\Delta_f S_m^\theta (\text{O}_2(\text{g})) = 205.14 \text{ J K}^{-1} \text{ mol}^{-1}$  and  $\Delta_f S_m^\theta (\text{H}_3\text{COOH}(\text{l})) = 159.8 \text{ JK}^{-1}\text{mol}^{-1}$ . **(4mks)**

b) The standard enthalpy of combustion of solid Urea ( $\text{CO}(\text{NH}_2)_2$ ) is  $-632\text{KJmol}^{-1}$  at 298K and its standard molar entropy is  $104.6 \text{ JK}^{-1}\text{mol}^{-1}$ . Calculate the standard Gibbs energy of the formation of urea **(4mks)**

c) The equation for the ionization of silver and chlorine is given as,  $\text{Ag}(\text{s}) + 1/2 \text{Cl}_2(\text{g}) \rightarrow \text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq})$ . If  $\Delta_r G^\theta = -54.12 \text{ kJ mol}^{-1}$  and  $\Delta_f G^\theta (\text{Ag}^+, \text{aq}) = +77.11 \text{ kJ mol}^{-1}$ , Calculate the standard Gibbs energy of formation of chloride ions **(3mks)**

d) Calculate the change in the molar Gibbs energy of water vapour (treated as a perfect gas) when the pressure is increased isothermally from 1.0 bar to 2.0 bar at 298 K **(3mks)**

e) Define the following terms as used in phase equilibria:

i) Phase

ii) Boiling

iii) Boiling point.

**(3mks)**

**END//**