**UNIVERSITY OF JORDAN**
**CHEMICAL ENGINEERING DEPARTMENT**

**0905323 – CHEMICAL ENGINEERING THERMODYNAMICS 2**

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| **Name** | |
| **University ID** | |

| **Course** ChE Thermodynamics II (905323) | |
|---|---|
| **Exam** | Midterm |
| **Date** | Thursday, 19/4/2007 |
| **Time** | 20 minutes closed book part<br>60 minutes open book part |
| **Instructor** | Dr. Ali Al-matar |

| Problem | Full Mark | Mark |
|---|---|---|
| 1 | 20 | |
| 2 | 30 | |
| 3 | 20 | |
| 4 | 30 | |
| | | |
| **Total** | **100** | |

وقّع على القسَم التالي المتعلق بالغش الأكاديمي:

اقسم بالله أنني لم اغش في هذا الامتحان ولم أساعد أي شخص على الغش سواءً لمنفعتي الشخصية أو لمنفعة الآخرين، وعلى هذا أوقّع.

التوقيع:

**1. (20 marks)**

**Select the most correct answer and circle it in the provided answers sheet. More than one answer may be correct, make your choices carefully and wisely.**

1. The behavior of the entropy function is oscillating during the approach to equilibrium

**a) True** **b) False**

2. $d^2S = 0$ provides a condition for

**a)** a metastable equilibrium state **b)** unstable equilibrium state **c)** a true equilibrium state **d)** None of these

3. At equilibrium in a system at constant $T$ and $P$, one of these properties is a minimum

**a)** $S$ **b)** $G$ **c)** $H$ **d)** $A$

4. A $T > T_c$ isotherm has _____ point(s) for which $\left(\frac{\partial P}{\partial v}\right)_T = 0$.

**a)** no (zero) **b)** one **c)** two **d)** three

5. The thermal stability criteria dictates that

**a)** $\kappa = 0$ **b)** $c_P \geq 0$ **c)** $c_V = 0$ **d)** $c_V > 0$

6. The second order transition of $SiO_2$ from the $\alpha$ to the $\beta$-quartz phase occurs where

**a)** $g$ is continuous **b)** $dg$ is continuous **c)** $d^2g$ is discontinuous **d)** All of these

7. The units of fugacity coefficient are units of

**a)** $P$ **b)** $T$ **c)** $v$ **d)** Dimensionless

8. Chemical equilibrium dictates that the composition of each component in various phases must be the same

**a) True** **b) False**

9. The derivative of Gibbs free energy with respect to pressure at constant temperature is

**a)** $P$ **b)** $T$ **c)** $v$ **d)** $\kappa$

10. The Poynting factor is important at

**a)** Extremely low $P$ **b)** High $P$ **c)** At all $P$ **d)** Only at high $P$ and low $T$

11. The partial molar enthalpy is defined as

**a)** $\bar{h}_i = \left.\frac{\partial(Nh)}{\partial N_i}\right|_{T,P,N_{j\neq i}}$ **b)** $\bar{h}_i = \left.\frac{\partial(Nh)}{\partial x_i}\right|_{T,P,x_{j\neq i}}$ **c)** $\bar{h}_i = \left.\frac{\partial(H)}{\partial N_i}\right|_{T,P,N_{j\neq i}}$ **d)** a and c

12. The volume change on mixing for an ethanol-water mixture is

**a)** Positive **b)** Negative **c)** Zero **d)** Changes sign

13. $\lim_{x_i \to 1} \left( \bar{\theta}_i - \theta_i \right) \to ?$

**a)** maximum **b)** minimum **c)** 0 **d)** $\infty$

14. The relationship expressed in the following equation: $x_1 \left( \frac{\partial \bar{h}_1}{\partial x_1} \right)_{T,P} dx_1 + x_2 \left( \frac{\partial \bar{h}_2}{\partial x_1} \right)_{T,P} dx_2 = 0$ is called

**a)** Lewis-Randall **b)** Gibbs-Pitzer **c)** Gibbs-Duhem **d)** Gibbs-Duhem-Pitzer

15. An ideal mixture (solution) is defined such that

**a)** $\Delta v_{mix}^{IM} = 0$ **and** $\Delta h_{mix}^{IM} = 0$ **b)** $\Delta v_{mix}^{IGM} = 0$ **and** $\Delta h_{mix}^{IM} = 0$ **c)** $\Delta v_{mix}^{IM} = 0$ **and** $\Delta u_{mix}^{IM} = 0$ **d)** $\Delta v_{mix}^{IM} = 0$ **and** $\Delta a_{mix}^{IM} = 0$

16. The compressibility factor for an ideal gas mixture is

**a)** $Z = 1$ **b)** $Z \to 0$ **c)** $Z > 1$ **d)** $Z < 1$

17. The relative volatility for a certain binary mixture is found to be $\alpha_{1,2}$=0.1. Therefore, component 1 will most likely concentrate in the vapor phase.

**a) True** **b) False**

18. Negative deviations from Raoult's law are manifested on a *Pxy* plot as

**a)** Bubble curve below Raoult's line **b)** Bubble curve above Raoult's line **c)** Dew curve below Raoult's line **d)** Dew curve above Raoult's line

19. Raoult's law is derived under the assumption that the liquid phase fugacity can be described by

**a)** IGM **b)** IM **c)** Real mixture **d)** None of these

20. A system will flash if the system pressure is higher than the dew point pressure and lower than the bubble point pressure

**a) True** **b) False**

**2. (30 marks)** for saturated steam at 1 atm

a) determine the fugacity and the fugacity coefficient using:
    a. steam tables,
    b. generalized charts, and
    c. the PR-EOS

b) Prove; using steam tables; that the fugacity is equal between saturated steam and water at the given conditions.

c) Comment on your results.

**3. (20 marks)** Use the sulfuric acid-water enthalpy chart to solve the following two parts:

a) If pure liquid $H_2SO_4$ at 21.1°C is added adiabatically to pure liquid water at 21.1°C to form a 40-wt-% solution, what is the final temperature of the solution?

b) For a 60-wt-% aqueous solution of $H_2SO_4$, what is the boiling point?

c) For a 60-wt-% aqueous solution of $H_2SO_4$ at 0°C, what is the heat of mixing?

**4. (30 marks)** a 20,000-liter storage tank was taken out of service to repair and reattach a feed line damaged in a collision with a tanker. The tank was drained and then opened several days later for a welder to enter and perform the required work. No one realized, however, that 15 liters of liquid nonane ($C_9H_{20}$) remained in a collection sump at the bottom of the tank after the draining had been completed.

a) Nonane has a lower explosion limit of 0.8 mole % and an upper explosion limit of 2.9 mole % (i.e., nonane-air mixtures at 1 atm can explode when exposed to a spark or a flame if the nonane mole fraction is between the two given values). Assume any liquid nonane that evaporates spreads uniformly throughout the tank. Is it possible for the average gas-phase composition in the tank to be within the explosion limits at any time? Even when the average composition falls outside those limits, why is an explosion still a possibility? (*Hint*: Think about that assumption.) The specific gravity of liquid nonane can be taken as 0.718.

b) Nonane has a vapor pressure of 5.0 mm Hg at 25.8ºC and 40.0 mm Hg at 66.0ºC. Use the Clausius-Clapeyron equation to derive an expression for the vapor pressure of nonane as a function of temperature. Then calculate the temperature at which the system would have to equilibrate in order for the gas in the tank to be at the lower explosion limit.

c) Fortunately, a safety inspector examined the system before the welder began work and immediately canceled the work order. The welder was cited and fined for violating established safety procedures. One requirement was for the tank to be purged thoroughly with steam after being drained. What is the purpose of this requirement? (Why purge, and why with steam rather than air?) What other precautions should be taken to be sure that the welder is in no danger?