UNIVERSITY OF JORDAN
CHEMICAL ENGINEERING DEPARTMENT

0905323 – CHEMICAL ENGINEERING THERMODYNAMICS 2

Name	
University ID	

Course	ChE Thermodynamics II (905323)
Exam	Final
Date	Tuesday, 23/1/2007
Time	20 minutes closed book part 100 minutes open book part
Instructor	Dr. Ali Al-matar

Problem	Full Mark	Mark
1	10	
2	3	
3	5	
4	8	
5	10	
6	6	
7	8	
Total	50	

وقّع على القسَم التالي المتّعلق 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:

Question 1 (10 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 entropy function is monotonically increasing during the approach to equilibrium

a) True **b) False** **c)** **d)**

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 closed system at constant T and V, one of these properties is a minimum

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

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

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

5. The equation: $\left(\frac{\partial P^{sat}}{\partial T}\right)_{g^I = g^{II}} = \frac{\Delta s}{\Delta v} = \frac{\Delta h}{T \Delta v}$ is called

a) Clapeyron **b)** Clausius-Clapeyron **c)** Harlecher-Braun **d)** Riedel

6. Ferromagnetic to paramagnetic is a second order phase transition where

a) g is continuous **b)** g is discontinuous **c)** d^2g is discontinuous **d)** a and c

7. $\lim_{P \to 0} \phi =$

a) 0 **b)** 1 **c)** P **d)** ∞

8. The reduced covolume (B) used frequently in equations of state is defined as

a) $B = \frac{b^2 P}{RT}$ **b)** $B = \frac{bP}{RT^2}$ **c)** $B = \frac{bP}{RT}$ **d)** $B = \frac{bP}{(RT)^2}$

9. A good initial guess for solving for the liquid phase compressibility factor is

a) a **b)** A **c)** b **d)** B

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 volume is defined as

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

12. To determine the partial molar Gibbs free energy, which of these experimental measurements are most appropriate?

a) Density **b)** Heat of mixing **c)** Phase equilibria **d)** Spectroscopic

13. A suitable measuring instrument for the heats of mixing would be

a) Pycnometer **b)** DSC **c)** Dynamic VLE still **d)** Static VLE still

14. $\lim_{x_i \to 0}\left(\bar{\theta}_i - \theta_i\right) \to ?$

a) maximum **b)** minimum **c)** 0 **d)** ∞

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

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

16. An ideal gas mixture is defined such that

a) $\Delta v_{mix}^{IGM} = 0$ **and** $\Delta G_{mix}^{IGM} = 0$ **b)** $\Delta u_{mix}^{IGM} = 0$ **and** $\Delta A_{mix}^{IGM} = 0$ **c)** $\Delta v_{mix}^{IGM} = 0$ **and** $\Delta u_{mix}^{IGM} = 0$ **d)** $\Delta v_{mix}^{IGM} = 0$ **and** $\Delta A_{mix}^{IGM} = 0$

17. The compressibility factor for an ideal gas mixture is

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

18. An ideal mixture is defined such that

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

19. The activity coefficient for an ideal solution is defined such that

a) $\ln \gamma = 0$ **b)** $\ln \gamma = 1$ **c)** $\ln \gamma = f(T,P,\mathbf{x})$ **d)** $\ln \gamma \rightarrow$ maximum

20. The relative volatility for a minimum boiling azeotrope is

a) $\alpha_{1,2} = 1$ **b)** $\alpha_{1,2} = 0$ **c)** $\alpha_{1,2} = \infty$ **d)** $\alpha_{1,2}$ = minimum

21. Positive 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

22. The vapor pressure of CO_2 at 20°C is 56.3 atm. Its ideal solubility at 1 atm is

a) 0.00112 **b)** 0.00563 **c)** 0.0178 **d)** 56.3

23. Ideal solid solubility

a) Always increases with *P* **b)** Always increases with *T* **c)** is independent of the type of solvent and its properties **d)** b and c

24. Water and NaCl will form a __________liquid mixture and probably a _______solution.

a) simple, ideal **b)** simple, nonideal **c)** Nonsimple, ideal **d)** Nonsimple, nonideal

25. NRTL an activity coefficient model based on

a) Empirical fitting **b)** Local composition **c)** Group contribution **d)** Quantum mechanics

26. The value of the one-constant (two-suffix) Margules equation parameter A = 0.5. This implies

a) $\gamma = 0$ **b)** $\gamma = 1$ **c)** $\gamma > 0$ **d)** $\gamma > 1$

27. One limitation of the Wilson's model is that it is

a) Unable to deal with LLE **b)** Unable to deal with LLE and VLE **c)** Unphysical model values. **d)** Good for LLE but unable to deal with VLE

28. The residual contribution in UNIFAC accounts largely with

a) size differences **b)** shape differences **c)** energy differences **d)** a and b

29. The combining rule for use with critical temperatures assumes the form of

a) arithmetic mean **b)** harmonic mean **c)** geometric mean **d)** None of these

30. H_i is a strong function of temperature, its usual trend for solubility of gases is

a) decreases with *T* **b)** increases with *T* **c)** increases with *T* then decreases **d)** increases with *T* then reaches a plateau

2. (3 marks) The metal tin undergoes a transition from a gray phase to a white phase at 286 K at ambient pressure. Given that the enthalpy change of this transition is 2090 kJ/mole and that the volume change of this transition is -4.35 cm^3/mole, compute the temperature at which this transition occurs at 100 bar.

3. (5 marks) The partial molar enthalpies of species in a simple binary mixture can sometimes be approximated by the following expressions:

$$\bar{h}_1 - h_1 = a_1 + b_1 x_2^2$$
$$\bar{h}_2 - h_2 = a_2 + b_2 x_1^2$$

For these expressions show that b_1 must equal b_2.

4. (8 marks) For an equimolar mixture of ethane and *n*-butane at 373.15 K and 10 bar.

a) Compute the fugacities for ethane and *n*-butane using the virial equation of state.
b) Determine the fugacity in the mixture using the virial EOS.
c) (**Bonus: 4 marks**) Repeat parts a and b using the PR-EOS.
d) Comment on your results.

The following data are available regarding the virial coefficients:

$B_{\text{ET-ET}} = -1.15\times10^{-4}$, $B_{\text{BU-BU}} = -4.22\times10^{-4}$, $B_{\text{ET-BU}} = -2.15\times10^{-4}$ m^3/mol.

5. (10 marks) A vapor-liquid mixture of water (1) - furfural (2) is maintained at 1.013 bar and 109.5ºC. It is observed that at equilibrium, the water content of the liquid is 10 mol % and that of the vapor is 81 mol %. The temperature of the mixture is changed to 100.6ºC, and some (but not all) of the vapor condenses. Assuming that the vapor phase is ideal and, and the liquid-phase activity coefficients are independent of temperature but dependent on concentration. Compute the equilibrium vapor and liquid compositions at the new temperature.

The following data are available regarding vapor pressure:

$$P_{\text{H}_2\text{O}}^{\text{vap}}(T = 109.5^\circ\text{C}) = 1.4088 \text{ bar}, \quad P_{\text{Furf}}^{\text{vap}}(T = 109.5^\circ\text{C}) = 0.1690 \text{ bar},$$

$$P_{\text{H}_2\text{O}}^{\text{vap}}(T = 100.6^\circ\text{C}) = 1.0352 \text{ bar}, \quad P_{\text{Furf}}^{\text{vap}}(T = 100.6^\circ\text{C}) = 0.1193 \text{ bar}.$$

6. (6 marks) the equilibrium state in the carbon tetrachloride-water system at 25ºC is two phases: one an aqueous phase containing 0.9708×10^{-4} mol% CCl_4, and the other an organic phase containing 0.9403×10^{-3} mol% water.

a) Estimate the activity coefficient of CCl_4 in the aqueous phase and water in the organic phase.

b) Provide an estimate of the infinite dilution activity coefficients for CCl_4 in the aqueous phase and water in the organic phase.

7. (8 marks) Estimate the activity coefficients for a mixture of 0.5 mole fraction acetone and 0.5 mole fraction n-octane at 298.15 K. Comment on the results regarding the values of the activity coefficients and possible and plausible explanation.