University of Jordan
Faculty of Engineering and Technology
Chemical Engineering Department

ChE 905322 – Chemical Engineering Thermodynamics I

الاسم	:
الرقم الجامعي	:
المادة	: ديناميكا حرارية ١ (٩٠٥٣٢٢)
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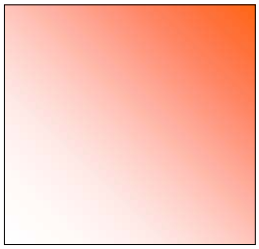
مدرس المادة	: د. علي المطر



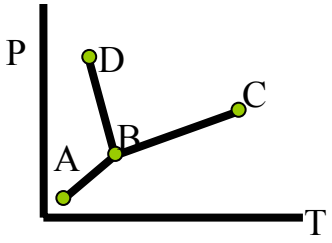
السؤال	١	٢	٣	٤	٥	٦	٧	٨	٩	١٠	١١	١٢
العلامة الكاملة	٤٥	٢٥	١٥	١٥	١٥	١٥						
العلامة												

وقع 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 أوقع.

التوقيع:

Question 1 (45 points). 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.Which point on the phase diagram above is the critical state?

a) A. b) B. c) C. d) D.

2.Which line on the above phase diagram corresponds to the Solid-Liquid transition?

a) A-B. b) B-C. c) B-D. d) There is no such line on this diagram.

3.What is the major point of similarity/difference between this diagram and that of water?

a) They have the same shape. b) Both diagrams have negative slope S-L line. c) They have different signs of the slopes for the S-V line. d) Both diagrams have the same V-L line.

4.Which point on the phase diagram above corresponds to the triple point?

a) A. b) B. c) C. d) D.

5.For an ideal gas, which of the following combinations can essentially be reduced to a single variable from an equation of state perspective

a) (T,P). b) (T,V). c) (T,U). d) (U,V).

6.Mathematically, the critical point is

a) An inflection point. b) Maximum point. c) Minimum point. d) Singularity.

7.The value of the latent heat of vaporization at the critical point is

a) Negative. b) Positive. c) Infinity. d) Zero.

8.A supercritical fluid is a fluid for which

a) $P>P_c$. b) $T<T_c$. c) $P>P_c$, and $T>T_c$. d) $T>T_c$.

9.The relationship between vapor and gas is

a) The gas is the general case (includes vapor). b) The vapor is the general case (includes gas). c) They are not related. d) None of these.

10.A subcooled liquid is a liquid for which

a) $T>T_b$. b) $T>T_c$. c) $T=T_b$. d) $T<T_b$.

11.The isotherms of the superheated vapor

a) Vary abruptly. b) Have single compressibility root. c) Occur whenever $T>T_b$. d) B and C.

12.The slope of any coexistence curve have a direct relationship to

a) Critical constants b) Normal boiling point. c) Latent heat associated with the phase change. d) The latent heat of vaporization.

13.The volume, enthalpy and entropy changes associated with phase transitions are

a) Always positive b) Always negative c) Never zero d) Can be positive or negative.

14.From a thermodynamic definition, the incompressible fluid is a fluid who has

a) $\beta=0$. b) $\kappa=0$. c) $\beta=0$, $\kappa>0$. d) $\beta=\kappa=0$.

15.The virial equation of state applies to:

a) Vapors only. b) Liquids only. c) Vapors and liquids. d) All phases of matter.

16. The virial coefficients are functions of

a) (T,P). b) (T,**x**). c) T only. d) (P,**x**).

17. The minimum and maximum numbers of real roots that can be solved for using cubic equations of state are

a) (1,1). b) (1,2). c) (1,3). d) (2,3).

18. The significance of having more than one real root when solving a cubic equation of state is:

a) Single phase region is obeyed regardless of the number of roots. b) Two phases exist even though we may have three roots. c) Three phases coexist because we have three roots. d) The solution is wrong, only one real root is allowed.

19. The ratio of heat capacities for oxygen is approximately

a) 1.67. b) 1.50. c) 1.40. d) 1.30.

20. When using a polytropic process to represent argon undergoing an isochoric process, the value of δ is:

a) 0. b) 1. c) 1.67. d) Infinity.

21. Work is to be supplied to a certain process. The reversible process requires work in the amount of 20 kJ. The efficiency of the process is measured to be 80%. What is the work (in kJ) of a real process?

a) 16.0. b) 12.5. c) 25.0. d) 4.0.

22. The temperature at which the second virial coefficient becomes zero is called

a) Boiler's T. b) Boiling T. c) Norm. boiling T. d) Boyle's T.

23. From a molecular perspective, all cubic equations of state can be written as two contributions:

a) Repulsive + Attractive. b) Repulsive – Attractive. c) Repulsive * Attractive. d) Repulsive / Attractive.

24. The value of the acentric factor for a simple fluid is:

a) Negative. b) Positive. c) 0. d) Infinity.

25. Which of these processes leads to the enthalpy of a substance being independent of the pressure?

a) Isothermal. b) Isobaric. c) Isochoric. d) Adiabatic.

26. The standard reference state for chemical reactions is defined as:

a) (25°C, 1 atm, simplest stable state). b) (25°C, 1 bar, simplest stable state). c) (0°C, 1bar, simplest stable state). d) (25°C, 1bar).

27. The enthalpy of formation for graphite is

a) Negative. b) Positive. c) 0. d) Infinity.

28. The gas in a cylinder similar to the ones used in Jordan, undergoes a throttling process from (T_1,P_1) to (T_2,P_2). Assuming that the gas behaves as an ideal gas, its T_2 will be such that:

a) $T_2 > T_1$. b) $T_2 = T_1$. c) $T_2 < T_1$. d) Increases then decreases.

29. At low temperatures, the values of the second (B) and third (C) virial coefficients are

a) B is negative, and C is positive. b) C is negative, and B is positive. c) Both are negative. d) Both are positive.

30. The critical compressibility factor predicted by the van der Waal's equation of state is

a) 0. b) 1/3. c) 3/8. d) Substance dependent.

Question 2 (25 points).
The gas cylinders distributed by Jordan Petroleum Refinery Company (JPRC), contain a mixture of propane and n-butane. Assume they contain only n-butane. The volume of the cylinder is about 30 liters. The cylinder has a temperature of approximately 25 °C, and a pressure of 7.0 bars.

a) Use the Peng-Robinson equation of state to determine the molar volume for the vapor and liquid phases. *Carry out at least three iterations for the root of each phase*.
b) The numerical values for the roots are such that: Z^V=0.778825, and Z^L=0.027211. Find the mass fraction of the liquid and that of the vapor if the total mass in the cylinder is 12 kilograms.

Solve either question 3 or 4.

Question 3 (15 points).
The vapor pressure of water is given by the Antoine equation

$$\ln P^{\text{sat}} / \text{kPa} = 16.2620 - \frac{3799.89}{T / ^\circ\text{C} + 226.35}$$

a) Using the Antoine equation, what is the latent heat of vaporization of water at 60 °C?
b) Estimate the latent heat of vaporization of water at 60 °C using the estimation methods discussed in class.
c) Compare the values you obtained with the value from the steam tables.

Question 4 (15 points).
A tank used to transport a certain petroleum fraction caused an explosion when it was traveling from Zarqa to Ma'an. Colonel Hussein, the civil defense officer who is assigned to investigating the cause(s) of the explosion is clueless. Consequently, he came to you asking for help. His investigations led to gathering the following information:

The tank capacity is 60 m^3. The log sheets of the operator in charge indicated that it was filled completely with the petroleum fraction.
The temperature in Zarqa that summer day was 20°C, and 35°C in Ma'an.
The properties on the day of the incident are: V=1.287 cm^3/g, β=0.001487/°C, and κ=0.000062/bar.
The metal sheet the tank is made of is designed to withstand a pressure of 300 bars.

Can you help him explain what happened i.e., suggest a scenario of the incident and why it happened? At what specific conditions did the incident happen?How can you prevent such incident from happening again?

Solve either question 5 or 6.

Question 5 (15 points).
It is sometimes necessary to produce saturated steam from superheated steam. This change can be accomplished in a *desuperheater*, a device in which just the right amount of water is sprayed into superheated steam to produce dry saturated steam. If superheated steam at 3.0 MPa and 500°C enters the desuperheater at a rate of 500 kg/hr, at what rate should liquid water at 2.5 MPa and 25°C be added to the desuperheater to produce saturated steam at 2.25 MPa?

Question 6 (15 points).

a. An adiabatic *turbine* expands steam from 500°C, 3.5 MPa to 200°C and 0.3 MPa. If the turbine generates 750 kW, what is the flow rate of steam through the turbine?
b. If a breakdown of the thermal insulation around the turbine allows heat loss of 60 kJ per kilogram of steam, and the exiting steam is at 150°C and 0.3 MPa, what will be the power developed by the turbine if the inlet steam conditions and flow rate are unchanged?

Student Name:

	(A)	(B)	(C)	(D)
❶	○	○	○	○
❷	○	○	○	○
❸	○	○	○	○
❹	○	○	○	○
❺	○	○	○	○
❻	○	○	○	○
❼	○	○	○	○
❽	○	○	○	○
❾	○	○	○	○
❿	○	○	○	○
⓫	○	○	○	○
⓬	○	○	○	○
⓭	○	○	○	○
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Fill the circles completely.
Don't fill more than one circle for each question. If there are more than one circles filled, you will get a zero for that question.
No answers on the questions sheet will be accepted.
Use a black/blue pen not a pencil.