UNIVERSITY OF JORDAN
CHEMICAL ENGINEERING DEPARTMENT

0905322 – CHEMICAL ENGINEERING THERMODYNAMICS 1

Name	
University ID	

Course	ChE Thermodynamics I (905322)
Exam	Final
Date	Saturday, 21/1/2006
Time	20 minutes closed book part 100 minutes open book part
Instructor	Dr. Ali Al-matar

Problem	Full Mark	Mark
1	30	
2	15	
3	30	
4	25	
Total	**100**	

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:

Student Name:

Question 1 (30 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. The latent heat of vaporization for a liquid with a normal boiling point temperature of 300 K according to Trouton's rule is
   a) 25 kJ/kg b) 25 kJ/mole c) 25 J/mole d) 25 J/kg

2. The device in which an irreversible process in which a fluid, flowing across a restriction, undergoes a drop in its pressure is called
   a) porous plug b) nozzle c) orifice d) a and c

3. The Joule-Thomson coefficient is defined as
   a) $\left(\frac{\partial \underline{V}}{\partial P}\right)_{\underline{H}}$ b) $\left(\frac{\partial T}{\partial P}\right)_{\underline{V}}$ c) $\left(\frac{\partial T}{\partial P}\right)_{\underline{H}}$ d) $\left(\frac{\partial P}{\partial T}\right)_{\underline{H}}$

4. The value of the specific heat at constant pressure of nitrogen assuming it to be an ideal gas
   a) 1.5R b) 2.5R c) 3.5R d) 4.5R

5. The term used to denote a phase change from vapor to solid is called
   a) evaporation b) melting c) deposition d) vaporization

6. The compressibility factor for an ideal gas is
   a) 0 b) 1 c) ∞ d) -1

7. The natural thermodynamic variables for the Helmholtz free energy are
   a) $T,\underline{V}$ b) T,P c) $\underline{H},P$ d) $\underline{S},P$

8. For an incompressible liquid, the value of the isothermal compressibility κ_T is
   a) 1 b) 0 c) -1 d) ∞

9. Typical pressure ratios in a standard Brayton cycle are
   a) 1-5 b) 1-10 c) 1-20 d) 5-20

10. Differences between the PR and SRK EOS are mainly in
    a) Repulsive term b) Attractive term c) κ d) b and c

11. If the Mach number of the shockwave accompanying a mechanical explosion is greater than one; then the shockwave is classified as?
    a) Supersonic b) Sonic c) Subsonic d) Ultrasonic

12. The energy released when 10 kg of TNT explode is
    a) 46 kJ b) 0.46 MJ c) 4.6 MJ d) None of these

13. The efficiency in the Linde process compared to the simple liquefaction process at the same operating conditions is
    a) Greater for Linde b) Greater for simple c) Equivalent d) May vary

14. Based on its origin, oil shale is classified as
    a) an alternative fuel b) biomass c) fossil fuel d) electrochemical

15. The refrigeration vapor compression cycle differs from the refrigeration Rankin cycle by replacing the turbine with
    a) a nozzle b) piston-cylinder c) throttling valve d) None of these

Student name:
Registration number:

	(A)	(B)	(C)	(D)
01	○	○	○	○
02	○	○	○	○
03	○	○	○	○
04	○	○	○	○
05	○	○	○	○
06	○	○	○	○
07	○	○	○	○
08	○	○	○	○
09	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○

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.

Question 2 (15 points)

Two kilograms of water at 90˚C are mixed with 5 kg of ice at 0˚C in an isolated system. The specific heat for water and ice can be taken as 4.18 kJ/kg.K, and the latent heat of melting the ice is 333.5 kJ/kg.

1. Calculate the entropy change and the final temperature.
2. Calculate the entropy change and the final temperature if one instead of 5 kilograms of ice were present.

Sketch	**Assumptions**

Solution

Question 3 (30 points)

A 16.9 m^3 process vessel containing liquid petroleum fraction that may be approximated by n-hexane is subjected to sudden rise in pressure and temperature that led to BLEV explosion. The temperature is 420 K at the vessel pressure which is 10 bars. The liquid heat capacity for n-hexane may be assumed constant at 200 J/mol.K. Also, the vapor pressure for n-hexane is given by Antoine's equation

$$\ln P(\text{bar}) = 9.2164 - \frac{2697.55}{T(\text{K}) - 48.78}$$

1. Use the Peng-Robinson EOS to find the mass of the liquid in the vessel. Use a proper initial guess and carry out 3 iterations.
2. The compressibility factor at the initial conditions is $Z = 0.0484$. What is the mass in the vessel?
3. Find the fraction of vapor that caused the explosion.
4. What is the TNT equivalent for this BLEV explosion?

Sketch	**Assumptions**

Solution

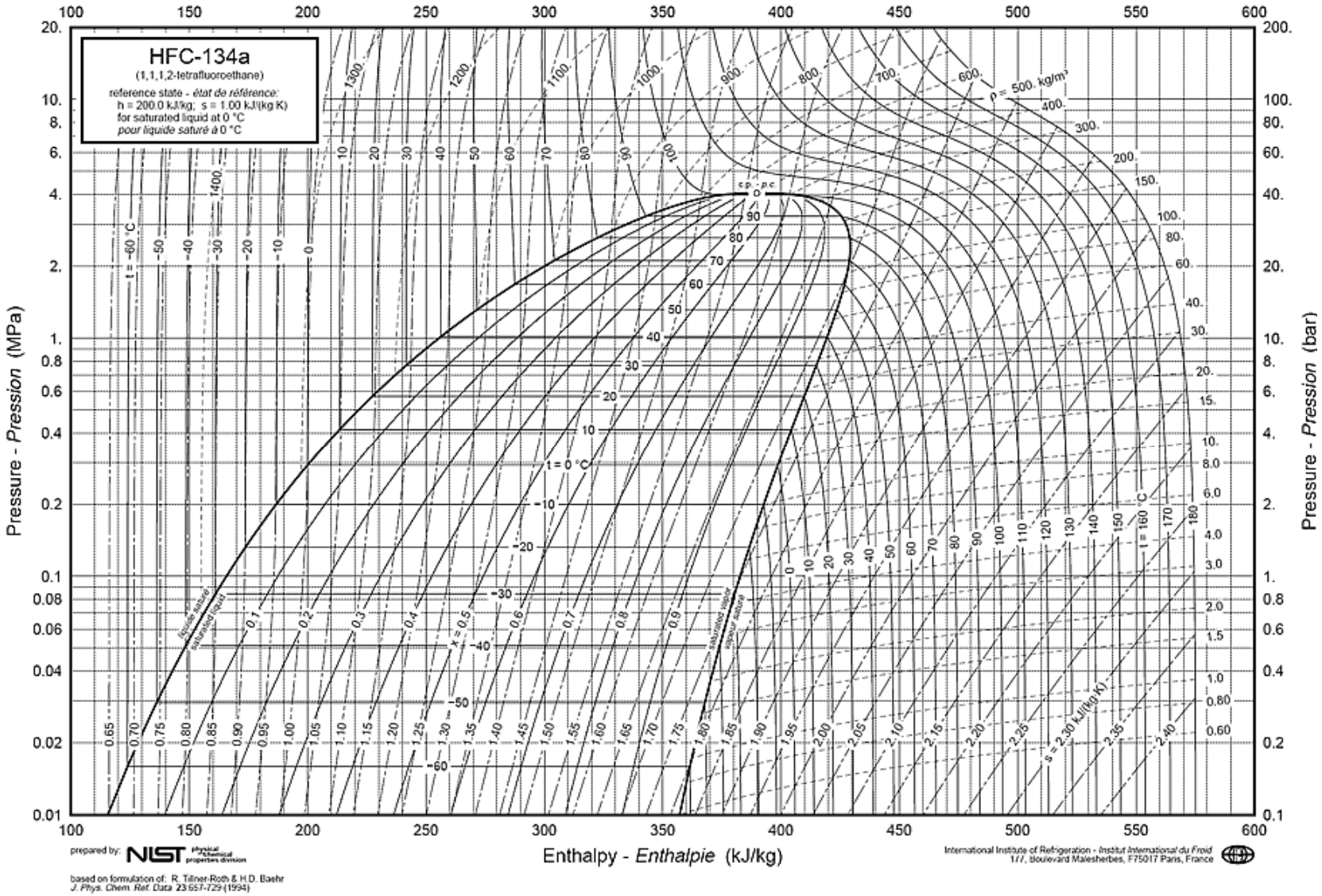
Question 4 (25 points)

An air conditioner uses vapor-compression refrigeration cycle with the environmentally friendly refrigerant HFC-134a as the working fluid. The cycle operates between 70˚C and -10˚C.

1. Supply the missing temperatures and pressures at each location in the provided table. Provide the vapor fraction if there are vapor-liquid mixtures.
2. Determine the COP for the cycle.
3. What is the efficiency of a Carnot cycle operating at the temperatures in the evaporator and condenser?
4. If the AC is rated at 20 kW, what is the power input to the compressor?
5. Find the volumetric flow rate for the refrigerant entering the compressor.

Sketch	**Assumptions**

Location	State	Process Path	T(˚C)	P (kPa)	$\underline{H}$ (kJ/kg)	$\underline{S}$ (kJ/kg.K)
1	Saturated liquid	Isenthalpic	70			
2						
3						
4						
1						


HFC-134a
(1,1,1,2-tetrafluoroethane)
reference state - état de référence:
h = 200.0 kJ/kg; s = 1.00 kJ/(kg K)
for saturated liquid at 0 °C
pour liquide saturé à 0 °C
Pressure - Pression (MPa)
Pressure - Pression (bar)
Enthalpy - Enthalpie (kJ/kg)
c.p. - p.c.
liquide saturé
saturated liquid
saturated vapor
vapeur saturé
prepared by: NIST Physical & Chemical properties division
based on formulation of: R. Tillner-Roth & H.D. Baehr
J. Phys. Chem. Ref. Data 23:657-729 (1994)
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