KATHMANDU UNIVERSITY
End Semester Examination
March/April, 2025

Level : B.E.
Year : II
Time : 2 hrs. 30mins.

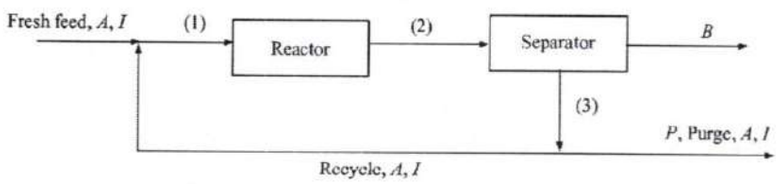
08 APR 2025

Course : CHEG 201
Semester : I
F. M. : 40

SECTION "B"

Assume suitable data if necessary.

1. For the reaction A→B, the process flow diagram is shown in the figure. The fresh feed A contains 0.5% of inerts by volume. 60% conversion of A per pass is obtained. The concentration of inerts going into the reactor at (1) must be held at 2% by volume. All streams are ideal gases and the process is at steady state. Find: [2+2+2]
   a. How many moles need to be recycled per mole of total feed to the reactor at (1)?
   b. How many moles need to be purged?
   c. What is the overall conversion of A?



2. Sodium phosphate is produced by the reaction of soda ash with phosphoric acid:

$$H_3PO_4 + Na_2CO_3 \rightarrow Na_2HPO_4 + CO_2 + H_2O$$
$$Na_2HPO_4 + NaOH \rightarrow Na_3PO_4 + H_2O$$

The first reaction is carried out by treating an aqueous solution of soda ash with commercial phosphoric acid containing 85% acid. The disodium phosphate solution is then treated with 50% caustic lye to produce 20% solution of trisodium phosphate in water. To produce 1000 kg of trisodium phosphate solution, calculate: [2+2]
   a. The quantity and composition of aqueous soda ash solution
   b. To weight ratio in which the soda ash solution and commercial phosphoric acid are to be mixed.

OR

Antimony is obtained by heating pulverized stibnite (Sb_2S_3) with scrap iron and drawing off the molten antimony from the bottom of the reaction vessel:

$$Sb_2S_3 + 3Fe \rightarrow 2Sb + 3FeS$$

Suppose that 0.600 kg of stibnite and 0.250 kg of iron turnings are heated together to give 0.200 kg of Sb metal. Determine. [2+2]
   a. The limiting reactant and percentage of excess reactant
   b. The yield in kilograms of Sb produced per kilogram of Sb_2S_3 fed to the reactor

3. What do you mean by dew point and bubble point? Calculate bubble point of a liquid mixture of 80 mol % *n*-hexane and 20 mol % *n*-pentane at 10343 mmHg. [6]

P.T.O.

4. The analysis of a gas mixture showed 30% O_2, 40% N_2, 10% CO_2 and 20% CH_4. The gas mixture is at 8 MPa and 15° and flows through a 2 cm diameter pipe at a speed of 3 m/s. Calculate the mass flow rate of the gas using *Kay's method*. [7]

5. Air is being compressed from 100 kPa and 255 K (where it has an enthalpy of 489 kJ/kg) to 1000 kPa and 278 K (where it has an enthalpy of 509 kJ/kg). The exit velocity of the air from the compressor is 60 m/s. What is the power required (in kilowatts) for the compressor if the load is 100 kg/hr of air? [5]

6. Liquid propane (C_3H_8) enters a combustion chamber at 25°C at a rate of 0.05 kg/min where it is mixed and burned with 50 percent excess air that enters the combustion chamber at 7°C. An analysis of the combustion gases reveals that all the hydrogen in the fuel burns to H_2O but only 90 percent of the carbon burns to CO_2, with the remaining 10 percent forming CO. If the exit temperature of the combustion gases is 1500 K, determine the mass flow rate of air and ΔH of the reaction. The following reaction and data table are provided. There will be excess O_2 and unreacted N_2 in the outlet stream. [6]

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

Species	H_f (kJ/kmol)	H_{280K} (kJ/kmol)	H_{298K} (kJ/kmol)	H_{1500K} (kJ/kmol)
C_3H_8 (l)	-118910	-	-	-
O_2	0	8150	8682	49292
N_2	0	8141	8669	47073
CO_2	-393520	-	9364	71078
CO	-110530	-	8669	47517
H_2O (g)	-241820	-	9904	57999

7. Moist air at dry bulb temperature of 30°C and 50% relative humidity is heated to 50°C at constant pressure of 1 am. [1.5+3+1.5]
   a. Determine the wet bulb temperature before heating
   b. Determine the relative humidity and dew point after heating
   c. Determine the amount of heat added per m^3 of initial moist air

Useful Information

Molecular Weights (g/mol):

H_3PO_4	98	CO_2	44	Sb_2S_3	680
Na_2CO_3	106	H_2O	18	Fe	56
Na_2HPO_4	142	NaOH	40	Sb	122
C_3H_8	44	Na_3PO_4	164	FeS	88
O_2	32	N_2	28	CH_4	16

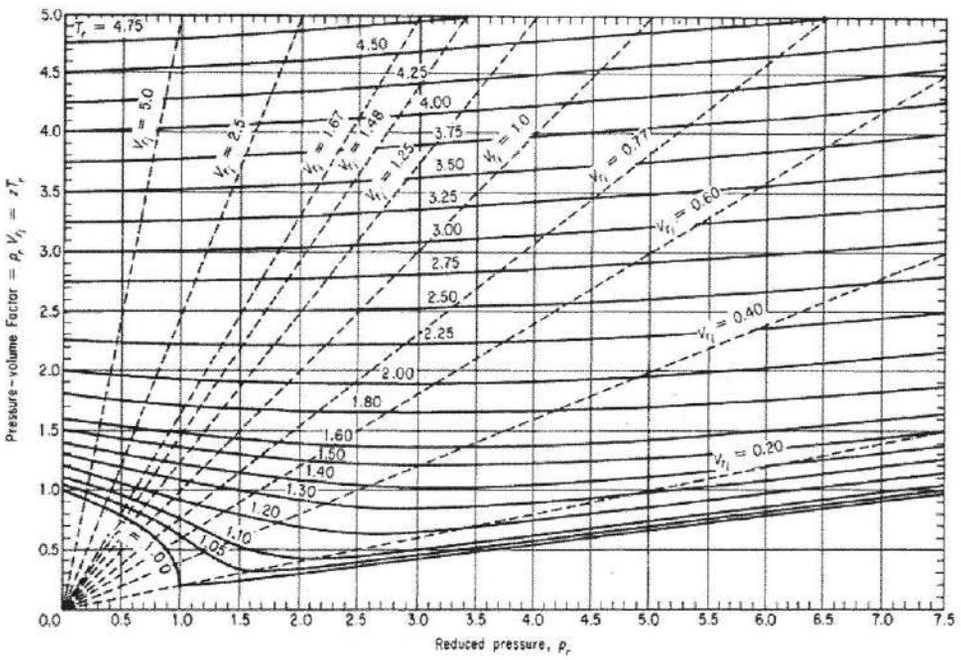


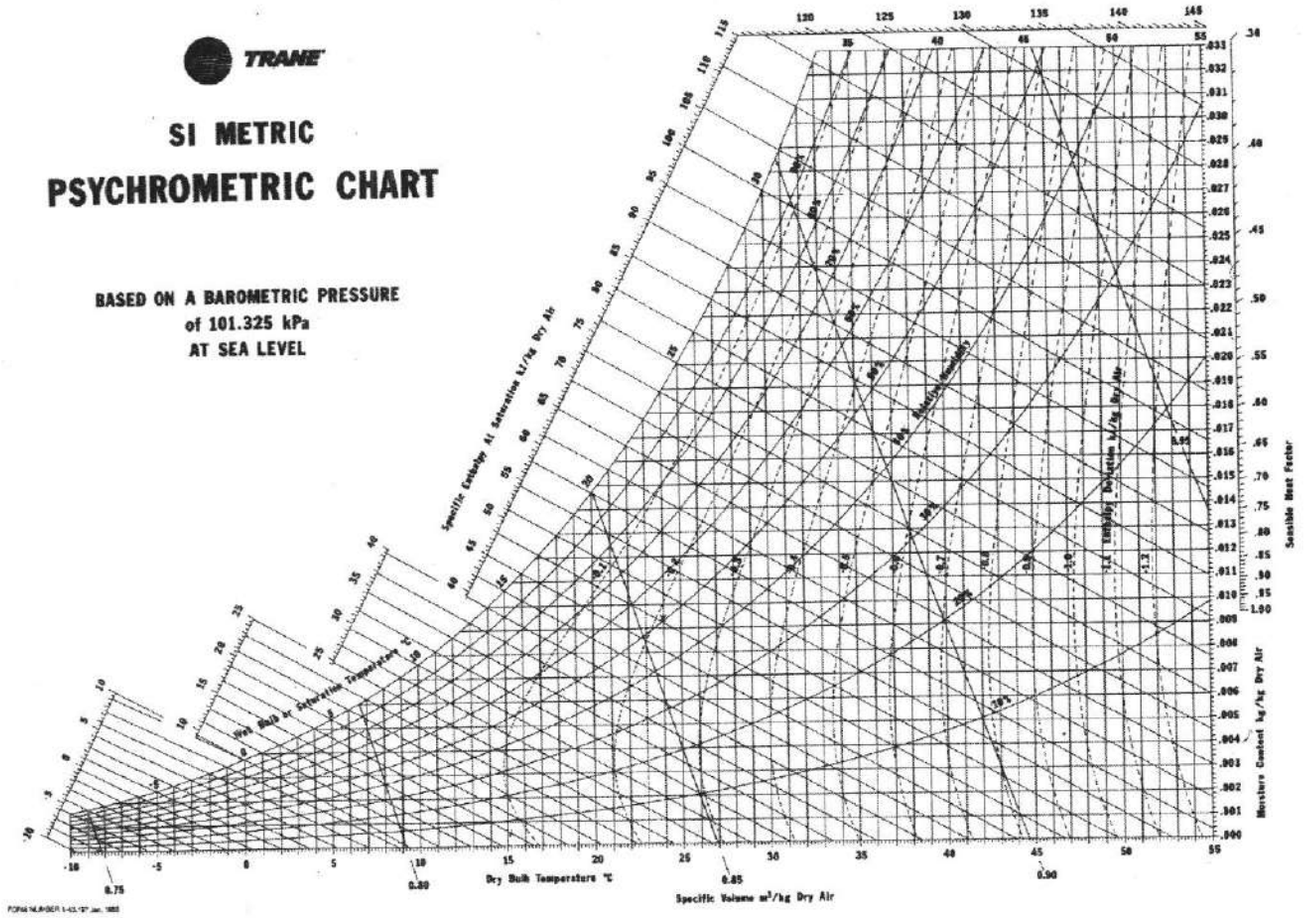
Figure 7.8b. Generalized compressibility chart for higher values of p_r

Physical Properties of Various Organic and Inorganic Substances

Component	T_c (K)	p_c (atm)
O_2	154.4	49.7
N_2	126.2	33.5
CO_2	304.2	72.9
CH_4	190.7	45.8

Values of the Universal Gas Constant R

Values of R	Units	Values of R	Units
8.314472	$J \cdot K^{-1} \cdot mol^{-1}$	83.14472	$L \cdot mbar \cdot K^{-1} \cdot mol^{-1}$
0.082057	$L \cdot atm \cdot K^{-1} \cdot mol^{-1}$	8.314472×10^{-5}	$m^3 \cdot bar \cdot K^{-1} \cdot mol^{-1}$
8.205745×10^{-5}	$m^3 \cdot atm \cdot K^{-1} \cdot mol^{-1}$	10.73159	$ft^3 \cdot psi \cdot °R^{-1} \cdot lb\text{-}mol^{-1}$
8.314472	$L \cdot kPa \cdot K^{-1} \cdot mol^{-1}$	0.73024	$ft^3 \cdot atm \cdot °R^{-1} \cdot lb\text{-}mol^{-1}$
8.314472	$m^3 \cdot Pa \cdot K^{-1} \cdot mol^{-1}$	1.98588	$Btu \cdot °R^{-1} \cdot lb\text{-}mol^{-1}$
82.05745	$cm^3 \cdot atm \cdot K^{-1} \cdot mol^{-1}$	62.36367	$L \cdot torr \cdot K^{-1} \cdot mol^{-1}$



Antoine equation:

$$\ln(p^*) = A - \frac{B}{C + T}$$

where p^* = vapor pressure, mm Hg
T = temperature, K
A, B, C = constants

Name	Formula	Range (K)	A	B	C
Acetic acid	$C_2H_4O_2$	290–430	16.8080	3405.57	−56.34
Acetone	C_3H_6O	241–350	16.6513	2940.46	−35.93
Ammonia	NH_3	179–261	16.9481	2132.50	−32.98
Benzene	C_6H_6	280–377	15.9008	2788.51	−52.36
Carbon disulfide	CS_2	288–342	15.9844	2690.85	−31.62
Carbon tetrachloride	CCl_4	253–374	15.8742	2808.19	−45.99
Chloroform	$CHCl_3$	260–370	15.9732	2696.79	−46.16
Cyclohexane	C_6H_{12}	280–380	15.7527	2766.63	−50.50
Ethyl acetate	$C_4H_8O_2$	260–385	16.1516	2790.50	−57.15
Ethyl alcohol	C_2H_6O	270–369	18.5242	3578.91	−50.50
Ethyl bromide	C_2H_5Br	226–333	15.9338	2511.68	−41.44
n-Heptane	C_7H_{16}	270–400	15.8737	2911.32	−56.51
n-Hexane	C_6H_{14}	245–370	15.8366	2697.55	−48.78
Methyl alcohol	CH_4O	257–364	18.5875	3626.55	−34.29
n-Pentane	C_5H_{12}	220–330	15.8333	2477.07	−39.94
Sulfur dioxide	SO_2	195–280	16.7680	2302.35	−35.97
Toluene	$C_6H_5CH_3$	280–410	16.0137	3096.52	−53.67
Water	H_2O	284–441	18.3036	3816.44	−46.13

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SECTION "A"

[20Q. × 0.5 = 10 marks]

Choose and Mark [X] in the most appropriate answer. Symbols have their usual meanings unless stated and missing parameters can be assumed suitably.

1. The concept of matter wave was suggested by
   [ ] Heisenberg [ ] Schrodinger [ ] Laplace [ ] De Broglie

2. Relations for group velocity and phase velocity are
   [ ] $v_g = \frac{w}{k}$ & $v_p = \frac{dw}{dk}$ [ ] $v_g = \frac{dw}{dk}$ & $v_p = \frac{k}{w}$
   [ ] $v_g = \frac{dw}{dk}$ & $v_p = \frac{w}{k}$ [ ] $v_g = \frac{w}{2k}$ & $v_p = \frac{2dw}{dk}$

3. What is the potential energy term in Schrodinger equation for a particle outside the boundaries of a confined one dimensional box?
   [ ] $V(x) = \infty$ [ ] $V(x) = 0$ [ ] $V(x) = \infty$ [ ] $V(x) = 1$

4. An electron propagating along x-axis passing through a slit of width $\Delta y = 1\text{nm}$. The uncertainty on the y-component of its velocity after passing through the slit is
   [ ] 7.322×10^5m/s [ ] 2.326×10^4m/s [ ] 3.436×10^5m/s [ ] 1.166×10^5m/s

5. For an energy state E of a photon gas, the density of state is proportional to
   [ ] $\sqrt{E}$ [ ] E [ ] $E^{3/2}$ [ ] E^2

6. For what value of T a metallic long thin superconducting wire produces a magnetic field of $1.05\times10^5\,A/m$ if the critical magnetic field of a metal at $0K$ is $1.5\times10^5\,A/m$ and its critical temperature is $9.20K$.
   [ ] $3.04K$ [ ] $4.05K$ [ ] $5.04K$ [ ] $2.09K$

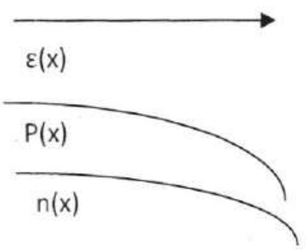
7. The diffusion coefficient of electron in silicon at 300K if $\mu_e = 0.19m^2/Vs$ is
   [ ] $1.36\times10^{-1}m^2/s$ [ ] $1.36\times10^{-3}m^2/s$ [ ] $4.9\times10^{-3}m^2/s$ [ ] $4.9\times10^{-1}m^2/s$

8. Which of the following parameters can't be found with Hall Effect?
   [ ] Polarity [ ] Conductivity
   [ ] Carrier concentration [ ] Area of the device

9. Given a *Si* sample is doped with 10^{17} $As\ atoms/cm^3$. The equilibrium hole concentration p_0 at $300K$ is

[ ] $0.25\times10^3 cm^{-3}$ [ ] $1.25\times10^3 cm^{-3}$ [ ] $2.25\times10^3 cm^{-3}$ [ ] $3.25\times10^3 cm^{-3}$

10. Which one is the correct drift and diffusion direction of electron and their resulting current density such that field is applied as shown in figure?



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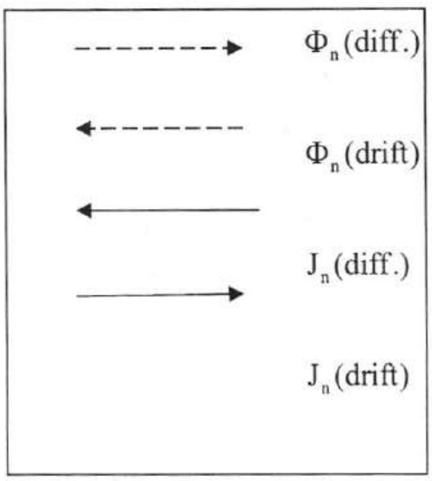

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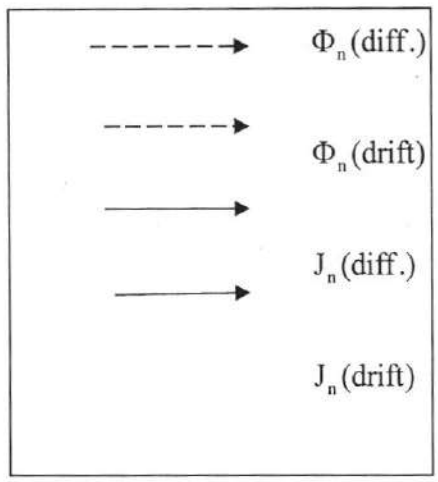

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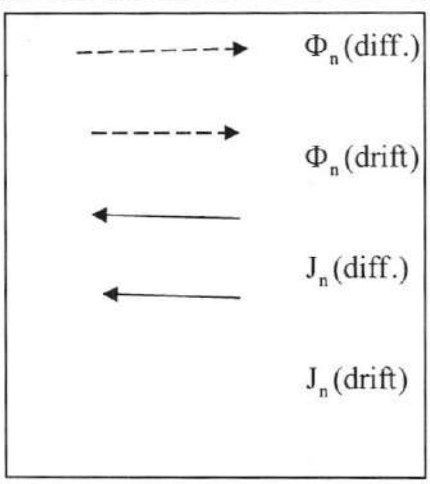

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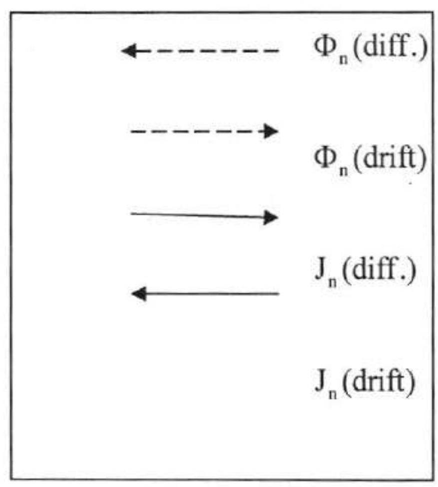

11. Interaction between the neighboring dipoles is negligible in the case of

[ ] diamagnetic material [ ] paramagnetic material

[ ] ferromagnetic material [ ] anti-ferromagnetic material

12. The orientation polarization takes place_____.
[ ] in polar dielectrics [ ] in non-polar dielectrics
[ ] in ionic dielectrics [ ] in all direction

13. The absorption coefficient for germanium at $\lambda = 400nm$ and $k = 2.215$ is
[ ] $6.96\times10^{6}\,m^{-1}$ [ ] $6.96\times10^{7}\,m^{-1}$ [ ] $5.96\times10^{6}\,m^{-1}$ [ ] $5.96\times10^{7}\,m^{-1}$

14. For which of the following diodes when the voltage is increased the current flowing through it decreases?
[ ] Tunnel Diode [ ] Schottky Diode [ ] Gunn Diode [ ] Laser Diode

15. When the air in a capacitor is replaced by a medium of a dielectric constant K, the capacity.....
[ ] decreases K times [ ] increases K times
[ ] increases K^2 times [ ] remains constant

16. In the photoelectric effect, the stopping potential of photoelectrons depends on _____.
[ ] both the frequency of incident light and the nature of the cathode material
[ ] the intensity of the incident light
[ ] only the frequency of the incident light
[ ] only the nature of the cathode material

17. Which of the following statement is **NOT** correct?
[ ] In order to decrease the eddy current core can be made of an insulator in order to decrease σ.
[ ] In order to decrease the eddy current core can be manufactured from iron powder where by each particle is covered by an insulating coating.
[ ] In order to decrease the eddy current is the utilization of cores made out of thin sheets which are electrically insulated from each other.
[ ] In order to decrease the eddy current is the utilization of cores made out of thin sheets which are electrically conducted from each other.

18. Piezoelectric effect is when materials produce electric charge when _____.
[ ] Voltage is applied [ ] Mechanical stress is applied
[ ] Electric field is applied [ ] Magnetic field is applied

19. Which one is the true statement about fluorescence spectroscopy of molecules in the UV-visible region?
[ ] Emission usually occurs at energies that are equal to the energies of excitation.
[ ] Emission usually occurs at energies that are less than the energies of excitation.
[ ] Emission usually occurs at energies that are slightly greater than the energies of excitation.
[ ] Emission usually occurs at energies that are moderately greater than the energies of excitation.

20. Soft solder is used for joining metal pieces is an alloy of _____.
[ ] Tin and Lead [ ] Tin and Zinc [ ] Zinc and Lead [ ] Copper and Lead