

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2017-2018

Sub: **CHEM 131** (Physical Chemistry I)

Full Marks: 210

Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

**SECTION – A**There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) What is the composition of a colloidal system? How a colloidal solution differs from a true solution? (5)
- (b) What is meant by peptization? Describe a method for the preparation of colloid by peptization. How will you account for the source of electrical charge on the colloid thus prepared? (3+7+5=15)
- (c) What is electrophoresis? How does this phenomenon provide information about the sign of charge on sol? How charge on a protein sol changes with pH? (3+7+5=15)
  
2. (a) Explain the connection between vapour pressure and boiling point. (5)
- (b) Define isotonic, hypertonic and hypotonic solutions. (3+7+5=15)
- Why must the concentration of a solution injected into the bloodstream be carefully controlled? Why salt can be used to protect meat and sugar can be used to protect fruits?
- What concentration of NaCl in water is needed to produce an aqueous solution isotonic with blood ( $\Pi = 7.70$  atm at 25°C).
- (c) What is reverse osmosis? How this phenomenon can be utilized for desalination of seawater? (6+4+5=15)
- Define van't Hoff factor (i) and thus state the modified equations for depression of freezing point ( $\Delta T_f$ ) and osmotic pressure ( $\Pi$ ) of electrolyte solution based on i.
- The observed osmotic pressure for a 0.10 M solution of  $\text{Fe}(\text{NH}_4)(\text{SO}_4)_2$  at 25 °C is 10.8 atm. Compare the expected and experimental values of i.
  
3. (a) Explain the phenomenon “escaping tendency of the solvent molecules” based on Raoult’s law. (5)
- (b) State separately the equations of partial vapour pressures for a completely miscible liquid pair system following both the Raoult’s law and Duhem-Margules law. (5+10=15)
- Draw and explain the P-C diagrams showing the positive and negative deviations from Raoult’s law for a completely miscible liquid pair system.

## CHEM 131

### Contd... Q. No. 3

- (c) What are meant by fractional distillation and steam distillation? (5+10=15)  
Sketch a steam distillation system and describe the principle and operation in purifying octane from a mixture.
4. (a) Explain the term "inverted solubility". (5)  
(b) Draw the solubility curves for KNO<sub>3</sub> and NaCl, and thus explain how KNO<sub>3</sub> can be separated from a mixture of KNO<sub>3</sub> and NaCl. Explain the effect of temperature on the solubilities of KNO<sub>3</sub> and NaCl in water based on Clausius-Clapeyron principle. (10+5=15)  
(c) What is meant by "energetics of dissolution"? Draw an energy profile and identify possible thermal processes during dissolution. (8+7=15)  
How concentration of electrolytes in intravenous fluids is expressed?  
A physiological saline solution contains 154 mEq/L each of Na<sup>+</sup> and Cl<sup>-</sup>. How many moles each of Na<sup>+</sup> and Cl<sup>-</sup> are in 250 mL of the saline solution?

### SECTION - B

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols used have their usual meaning. Assume reasonable values for any missing data.

5. (a) Justify: (20)  
(i) The mixing process of two individual gases is accompanied by an increase in entropy.  
(ii) The variation of equilibrium constant with temperature can provide information about the endothermic and exothermic nature of reactions.  
(b) Rationalize: (15)  
(i) As criteria of spontaneity in term of entropy change we consider  $\Delta S_{univ} > 0$  but in term of free energy change we consider  $\Delta G_{sys} < 0$ .  
(ii) For the reaction  $AgClO_2(s) = Ag(s) + \frac{1}{2} Cl_2(g) + O_2(g)$ ;  $\Delta H \approx 0$ , nevertheless, the process is spontaneous.
6. (a) Define free energy. Show that at constant T and P,  $-\Delta G$  represents the maximum available energy for doing useful work. (11)  
(b) Derive an expression for the dependence of  $\Delta G$  of a chemical reaction with temperature relating  $\Delta H$  of the reaction. (12)  
(c) Use the expression obtained from Q6(b) to find the general equations for  $\Delta H$  and  $\Delta S$  for the synthesis of ammonia  $[N_2(g) + 3H_2(g) = 2NH_3(g)]$ , if  $\Delta G = -9190 + 7.12T \ln T - 3.182 \times 10^{-3}T^2 - 1.32 \times 10^{-7}T^3 - 21.61T$ . (12)  
Will the reaction be spontaneous at 1000k?

## CHEM 131

7. (a) What is chemical potential? Establish a relation between the chemical potential and the partial pressure of a gas in a mixture. How can the partial pressure be replaced with the solute activity for any real solution? (11)
- (b) Define fugacity and activity. Explain how fugacity and activity terms are used instead of pressure for free energy expressions of real gases. (12)
- (c) Calculate the free energy change accompanying the compression of one mole of  $\text{CO}_2$  at  $60^\circ\text{C}$  from 25 atm to 300 atm. Apply the fugacity and activity concept to calculate the free energy change for the process at the same temperature, and comment on the result. (Given: the activity coefficients of  $\text{CO}_2$  at  $60^\circ\text{C}$  are 0.928 and 0.373 at 25 atm and 300 atm, respectively). (12)
8. (a) What are coupled reactions? With a suitable example explain how a thermodynamically non-spontaneous reaction becomes spontaneous being coupled with a highly spontaneous reaction. (11)
- (b) Define 'thermodynamic equilibrium constant'. Establish a relation between the standard free energy change and the thermodynamic equilibrium constant of a reaction. (12)
- (c) With a suitable mathematical support explain how an inert gas affects the equilibrium of a reaction. At  $394^\circ\text{C}$  and a total pressure of 1 atm the degree of dissociation of phosgene is 0.206. If  $\text{N}_2$  with a partial pressure of 0.40 atm is introduced into the system with a total equilibrium pressure of 1 atm, find the value of the degree of dissociation of phosgene. (12)
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2017-2018

Sub: **PHY 155** (Structure of Matter, Electricity and Magnetism & Modern Physics)

Full Marks: 210

Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

**SECTION – A**There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Briefly describe the Galilean transformation of co-ordinates of a particle in an inertial frame of reference with respect to another which is moving with a constant velocity. What are the failures of Galilean transformation? (10)
- (b) Why scientist assumed 'Luminiferous Ether' as the medium for the propagation of light in the 19<sup>th</sup> century? Describe the Michelson-Morley experiment to find the fringe shift and show that Ether does not exist. (18)
- (c) An observer in S' frame is moving to the right at a speed of 0.55c away from the stationary observer in frame S. The observer in S' measures the velocity v' of a particle moving to the right away from the observer. What speed v does the observer in S measure for the particle if i) v' = 0.60c? and (ii) v' = 0.99c? (7)
2. (a) What are the failures of classical physics for which quantum mechanics is introduced? (5)
- (b) Describe an experiment for studying photo-electric and establish Einstein's photo-electric equation. What are the experimental characteristics obtained there from? (22)
- (c) Light of wavelength 4300 Angstrom is incident on (i) nickel surface of work function 5 eV and (ii) potassium surface of work function 2.3 eV. Find out, if electrons will be emitted, and if so, the maximum velocity of the emitted electrons in each cases. (8)
3. (a) Briefly describe alpha decay,  $\beta^+$  decay,  $\beta^-$  decay (positron emission), electron capture and gamma radiation with examples. (10)
- (b) Define Q value of a nuclear reaction. Show that the total kinetic energy of particles relative to a centre of mass system in the laboratory system is given by (18)
$$KE_{cm} = \left( \frac{m_B}{m_A + m_B} \right) KE_{lab}$$

Where the terms have their usual meanings. Explain the condition when Q is positive and negative.

- (c) Find the minimum kinetic energy in the laboratory system needed by an alpha particle to cause the reaction  ${}^{14}\text{N}(\alpha, p){}^{17}\text{O}$ . The masses of  ${}^{14}\text{N}$ ,  ${}^4\text{He}$ ,  ${}^1\text{H}$  and  ${}^{17}\text{O}$  are respectively 14.00255 u, 4.00255u, 1.00782 u and 16.9915 u. (7)
4. (a) What is an electric dipole? Calculate the electric field due to an electric dipole at a point on the perpendicular bisector of the dipole. (12)
- (b) State Gauss's law and apply this law to obtain an expression for the electric field at a point (i) inside (ii) outside and (iii) surface of a uniformly charged non-conducting solid sphere. All expressions must be calculated in terms of charge density  $\rho$ . (16)

**PHY 155****Contd... Q. No. 4**

(c) The length and radius of a plastic rod are 200 cm and 4 mm, respectively. The rod carries a negative charge of magnitude  $12\mu\text{C}$ , spread uniformly over the surface. What is the electric field near the midpoint of the rod, at a point on its surface? (7)

**SECTION - B**

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Define electric field strength and electric potential. Find the relation between them. (7)  
 (b) Prove that the potential at a point in an electric field (20)  
 (i) due to a point charge is  $V = \frac{1}{4\pi\epsilon_0} \frac{q}{r}$  and  
 (ii) due to an electric quadrupole is  $V = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^3}$   
 where the symbols have their usual meanings.  
 (c) Three equal charges of +6 nC are located at the corners of an equilateral triangle whose sides are 12 cm long. Find the potential at the centre of the base of the triangle. (8)
6. (a) Explain about self-inductance and mutual inductance. (5)  
 (b) A circuit contains an inductance L and resistance R placed in series with a battery of emf  $\epsilon$ . Obtain expressions for the growth and decay of current in the circuit. What is the time constant of the circuit? (20)  
 (c) An inductor L, a resistance R and an emf =  $V_0$  are connected in series with a switch. The switch is pushed closed at  $t = 0$ . Find the following: (10)  
 (i) current at  $t = 0$  and at  $t = 0.5L/R$   
 (ii) induced emf at  $t = 0$  and at  $t = 0.5L/R$
7. (a) What's are the difference between crystalline and amorphous solids? Write the name of the seven types of crystal systems. (8)  
 (b) What are Bravais lattices? Draw bcc lattice unit cell. Show that the packing fraction for bcc lattice is about 68%. (17)  
 (c) What is lattice constant? Calculate the lattice constant of CsCl which has a SC lattice. The density of CsCl is  $4 \times 10^3 \text{ kg/m}^3$ , atomic weight of Cs = 132.9 and atomic weight of Cl = 35.5, Avogadro's number =  $6.02 \times 10^{26}$  per kg-mole. (10)
8. (a) What are Miller indices? Sketch the (112) and (111) planes in a simple cubic unit cell. (7)  
 (b) Explain the formation of a stable chemical bond using the potential energy versus interatomic distance curves. (10)  
 (c) What is an intrinsic semiconductor? Discuss the point defects in a crystal. (10)  
 (d) Lead is fcc lattice with an atomic radius of  $r = 1.746 \text{ \AA}$ . Find the spacing of (i) (220) planes and (ii) (111) planes. (8)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **HUM 125** (English)

Full Marks : 140

Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

**SECTION – A**

There are **FOUR** questions in this section. Answer any **THREE** questions including **Q. No. 1** as compulsory.

1. (a) Explain with references to the context any one of the following: (8)
- (i) “The geniuses of all ages and all groups speak different languages, but the same flame burns in them all.”
- (ii) “All these things, which another woman of her status would not have noticed, tortured and angered her.”
- (b) Answer any one of the following: (10)
- (i) Make a critical discussion on the note that the lawyer wrote before his departure from the jail.
- (ii) Give a character-sketch of Laura Sheridan according to the story of The Garden party.
- (c) Answer any three of the following: (12)
- (i) How was the weather of the weight on which the banker went out to kill the lawyer?
- (ii) Describe, the terms and conditions of the bet that was contracted between the banker and the lawyer.
- (iii) How were the feelings of Mrs. Matilda Loisel at the party, given by the Minister of Education?
- (iv) What impression do you get about Laura Sheridan’s mother?
2. Recast and correct any ten of the following sentences: (20)
- (i) This law is able to be evaded.
- (ii) The amount of horses on the range was small.
- (iii) The matter was to discussed between the electricians, the plumbers and the carpenters.
- (iv) I was in a dilemma about what to have for dinner.
- (v) They made less mistakes with the new calculating machine.
- (vi) Mrs. Phillips, together with some friends and neighbours, are planning a elaborative.
- (vii) It was them who was to do the work.
- (viii) Illiteracy is when a man cannot read or write.
- (ix) This is the case what I want.
- (x) There was a maverick besides the bush which the cowboy lassoed.
- (xi) He had a need and interest in athletics.
- (xii) He decided to work slow and easy.

**HUM 125(ChE)**

3. (a) Give the meanings of any ten of the following words: (10)

Aggravate, baffle, castigate, diffidence, feud, hamlet, indictment, laud, oblivion, pauper, retard, sporadic.

(b) Make sentences with any ten of the following words: (10)

Audacious, cataclysm, entire, gash, homage, jeopardy, meddle, nadir, phlegmatic, ramble, sinuous, vestige.

4. Write a précis of the following passage with a suitable title: (20)

The liberty of individual is no gift of civilization. It was unlimited before there was any civilization. Though then, it is true; it had for the most part no value, since the individual was scarcely in a position to defend it. The development of civilization imposes restrictions on it, and justice demands that no one shall escape those restrictions. What makes itself felt in a human community as desire for freedom may be their revolt against some existing injustices, and so many prove favourable to a farther development of civilization; it may remain compatible with civilization. The urge for freedom therefore, is directed against particular forms and demands of civilization, or against civilization altogether. It does not seem as though any influence could induce a man to change his nature into termite's. No doubt he will always defend his claim to individual liberty against the will of the group.

**SECTION – B**

There are **FOUR** questions in this Section. Answer any **THREE** questions including **Q. No. 5** as compulsory.

5. It is a great point to enlarge the range of studies which a University professes, even for the sake of the students; and though they cannot pursue every subject which is open to them. They will be the gainers by living among those and under those who represent the whole circle. This I conceive to be the advantage of a seat of universal learning, considered as a place of education. An assemblage of learned men, zealous for their own sciences, and rivals of each other, are brought by familiar intercourse and for the sake of intellectual peace, to adjust together the claims and relations of their respective subjects of investigation. They learn to respect, to consult, to aid each other. Thus is created a pure and clear atmosphere of thought, which the student also breathes, though in his own case he only pursues a few sciences out of the multitude. He profits by an intellectual tradition, which is independent of particular teachers, which guides him in his choice of subjects and duly interprets for him, those which he chooses. He apprehends the great outlines of knowledge, the principles on minimums, as he otherwise cannot apprehend them. Hence his education is called "Liberals". A habit of mind is formed which lasts through life, of which the attributes, are freedom, equitableness, calmness, moderation, and wisdom; or, which are termed philosophical habits. This them I would assign as the special fruit of the education furnished at a university, as

## **HUM 125**

### **Contd... Q. No. 5**

contrasted with other places of teaching or models of teaching. This is the main purpose of a University in its treatment of its students. **(30)**

Questions:

- (a) How does a University offer an overall gain to students?
  - (b) How does an intellectual peace develop?
  - (c) How does a student learn to promote an interaction between different fields of knowledge?
  - (d) What is "liberal" education? What is its impact on students?
  - (e) How is a University different from other places of learning?
  - (f) Give the meanings of the following words as used in the passage:  
Profess, conceive, assemblage, multitude, apprehend.
6. (a) You have received some products in a damaged condition from your suppliers. Write a letter of complaint emphasizing the need of greater care in complying with the orders. **(10)**
- (b) Write phonetic transcriptions of the following words: (Any five). **(10)**  
Abstract, page, father, think, hair, son.
7. (a) Write a dialogue between two customers about their concern for the adulteration of food. **(10)**
- (b) Write a short essay on any ONE of the following topics: **(10)**
- (i) My long cherished desire
  - (ii) Our young generation and their lifestyle
  - (iii) Depression: A psychic enemy
8. (a) Transform the following sentences as directed (Any five) **(10)**
- (i) She worked to the best of her ability. (Complex)
  - (ii) What he said is true. (Simple)
  - (iii) You can not buy things unless you have money. (Compound)
  - (iv) His failure is almost certain. (Complex)
  - (v) He writes so illegibly that I can not read his letter. (Compound)
  - (vi) He will not go unless, he is compelled. (Simple)
- (b) Write short notes on any TWO of the following: **(10)**
- (i) Diphthongs
  - (ii) Types of reports
  - (iii) Principles of business letter writing
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **MATH 123** (Integral Calculus and Differential Equations)

Full Marks: 210

Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks. The questions are equal value.

**SECTION - A**There are **FOUR** questions in this section. Answer any **THREE**.

1. Work out the following integrals:

(a)  $\int \frac{dx}{\cos(2x-a)\cos(2x+a)}$  (11)

(b)  $\int \frac{(2x+3)dx}{\sqrt{4x^2+2x+1}}$  (12)

(c)  $\int \frac{x^2}{(x \sin x + \cos x)^2}$  (12)

2. (a) Find a reduction formula for  $I_n = \int x \cos^n x dx$  and hence find  $\int x \cos^3 x dx$ . (12)

(b) Evaluate:  $\lim_{n \rightarrow \infty} \left[ \left(1 + \frac{1}{n^2}\right)^{2/n^2} \left(1 + \frac{2^2}{n^2}\right)^{4/n^2} \left(1 + \frac{3^2}{n^2}\right)^{6/n^2} \dots \left(1 + \frac{n^2}{n^2}\right)^{2n/n^2} \right]$  (11)

(c) Evaluate:  $\int_0^\pi \frac{x \tan x}{\sec x + \tan x} dx$  (12)

3. (a) Evaluate:  $\int_0^{16} \frac{(x)^{\frac{1}{4}}}{1+(x)^{\frac{1}{2}}} dx$  (11)

(b) Show that  $\int_0^\infty \frac{x^2 dx}{(x^2+a^2)(x^2+b^2)} = \frac{\pi}{2(a+b)}$ ,  $a, b > 0$  (12)

(c) Prove that

(i)  $\int_0^\infty x^4 e^{-4x} dx = \frac{3}{8} \sqrt{\pi}$  (6)

(ii)  $\beta(p+1, q) + \beta(p, q+1) = \beta(p, q)$  (6)

4. (a) Determine the area between the curves  $x^2 + 2y^2 = a^2$  and  $2x^2 + y^2 = a^2$ . (11)

(b) Find the perimeter of the loop of the curve  $9ay^2 = (x-2a)(x-5a)^2$ . (12)

(c) Find the volume of the solid formed by the revolution of the curve  $y^2(a+x) = x^2(3a-x)$  about the x-axis. (12)

## MATH 123

SECTION - B

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols used have their usual meaning.

5. (a) Find the differential equation of the family of curves,  $y = e^x(A \cos x + B \sin x)$ , where A and B are arbitrary constants. (10)
- (b) Solve:  $\cos x dx + \left(1 + \frac{2}{y} \sin x\right) dy = 0$ . (12)
- (c) Solve:  $\frac{dP}{dt} + 2tP = P + 4t - 2$ . (13)
6. (a) Solve:  $y dx + x(\ln x - \ln y - 1) dy = 0, y(1) = e$ . (11)
- (b) Solve:  $\frac{dy}{dx} - y \sec x = y^2 \sin x \cos x$ . (12)
- (c) A body at a temperature of  $50^\circ$  F is placed outdoors where the temperature is  $100^\circ$  F. If after 5 minutes the temperature of the body is  $60^\circ$  F, find (i) how long it will take the body to reach a temperature of  $75^\circ$  F and (ii) the temperature of the body after 20 minutes. (12)
7. (a) Find a differential operator that annihilates the function  $f(x) = 7x^3 - 5 + 3x^2 e^{-2x} + 3 \sin 2x$  and hence solve the differential equation  $y''' + 4y'' + 4y' = f(x)$ . (12)
- (b) Solve:  $16 \frac{d^4 y}{dx^4} + 24 \frac{d^2 y}{dx^2} + 9y = 0$  (11)
- (c) Solve:  $\frac{d^2 y}{dx^2} - y = \cosh x \cos x$ . (12)
8. (a) Solve:  $x^2 \frac{d^2 y}{dx^2} - 3x \frac{dy}{dx} + 5y = x^2 \sin(\ln x)$ . (11)
- (b) Solve:  $xy'' + (x-1)y' - y = x^2$  by the method of factorization operator. (12)
- (c) Solve:  $y \frac{d^2 y}{dx^2} - \left(\frac{dy}{dx}\right)^2 = y^2 \ln y$ . (12)
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **CHE 111** (Elements of Chemical Engineering)

Full Marks: 210

Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

**SECTION – A**There are **FOUR** questions in this section. Answer any **THREE**.

A data booklet containing all the necessary data is to be supplied.

1. (a) Write and simplify the closed-system energy balance for each of the following processes, and state whether nonzero heat and work terms are positive or negative. Begin by defining the system. (20)
- (i) The contents of a closed flask are heated from 25°C to 80°C.
  - (ii) A tray filled with water at 20°C is put into a freezer. The water turns into ice at 5°C. (When a substance expands it does work on its surroundings and when it contracts the surroundings do work on it.)
  - (iii) A chemical reaction takes place in a closed adiabatic (perfectly insulated) rigid container.
  - (iv) Repeat part (iii), only suppose that the reactor is isothermal rather than adiabatic and that when the reaction was carried out adiabatically the temperature in the reactor increased.
- (b) A small storage room whose dimensions are 2 m × 15 m × 3m contains a number of expensive and dangerous chemicals. To prevent unauthorized entry, the room door is always locked and can be opened with a key from either side. A cylinder of liquid carbon dioxide is stored in the room. The valve on the cylinder is faulty and some of the contents have escaped over the weekend. The room temperature is 25°C. (15)
- (i) If the concentration of CO<sub>2</sub> reaches the lethal 75 mole% level (at 75% death occurs in a matter of minutes), what would be the mole percent of O<sub>2</sub> in the room?
  - (ii) How much CO<sub>2</sub> (kg) is present in the room when the lethal concentration is reached?
  - (iii) Suggest at least three measures that would reduce the hazards associated with storage of this seemingly harmless substance.
2. (a) Superheated steam at 40 bar absolute and 500 °C flows at a rate of 250 kg/min to an adiabatic turbine, where it expands to 5 bar. The turbine develops 1500 kW. From the turbine the steam flows to a heater, where it is reheated isobarically to its initial temperature. Neglect kinetic energy changes. (20)
- (i) Write an energy balance on the turbine and use it to determine the outlet stream temperature.
  - (ii) Write an energy balance on the heater and use it to determine the required input (kW) to the steam.
  - (iii) Verify that an overall energy balance on the two-unit process is satisfied.

**CHE 111**

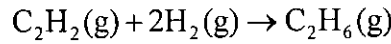
**Contd... Q. No. 2**

(b) The standard heat of combustion of gaseous acetylene is -1299.6 kJ/mol. (15)

(i) In your own words, briefly explain what that means. (Your explanation should mention the reference states used to define the tabulated heats of combustion.)

(ii) Use tabulated heats of formation to verify the given value of  $\Delta\hat{H}_c^\circ$ .

(iii) Calculate the standard heat of the acetylene hydrogenation reaction



Using (a) tabulated heats of formation and (b) tabulated heats of combustion

3. (a) A fuel gas containing 86% methane, 8% ethane, and 6% propane by volume flows to a furnace at a rate of 1450 m<sup>3</sup>/h at 15 °C and 150 kPa (gauge), where it is burned with 8% excess air. Calculate the required flow rate of air in SCMh (standard cubic meters per hour). (20)

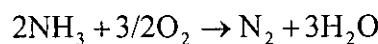
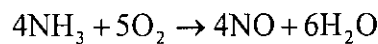
(b) Two hundred kg/min of steam enters a steam turbine at 350 °C and 40 bar through a 7.5-cm diameter line and exits at 75 °C and 5 bar through a 5-cm line. The exiting stream may be vapor, liquid, or “wet steam” (15)

(i) If the exiting stream were wet steam at 5.0 bar, what would its temperature be?

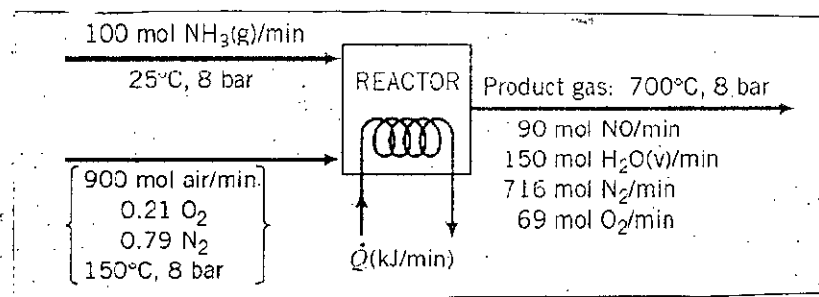
(ii) How much energy is transferred to or from the turbine? (Neglect  $\Delta E_p$  but not  $\Delta E_k$ )

4. (a) Discuss the procedures of energy balance on a reactive system by (i) heat of reaction method and (ii) heat of formation method with the help of hypothetical process path diagrams. (12)

(b) Ammonia is oxidized with air to form nitric oxide in the first step of the production of nitric acid. Two principal reactions occur: (23)



A flowchart of the reactor follows.



(i) Taking elemental species [N<sub>2</sub> (g), H<sub>2</sub> (g), O<sub>2</sub> (g)] at 25 °C as references, prepare and fill in an inlet-outlet enthalpy table.

(ii) Calculate the required rate of heat transfer to or from the reactor in kW.

## CHE 111

**SECTION - B**

There are **FOUR** questions in this section. Answer any **THREE**.

A data booklet (ChE 111/201 containing all the necessary data is to be supplied

5. (a) Vapor pressure of Benzene in the range of 7.5 °C to 104 °C is given by: (15)

$$\log_{10} p = 6.9057 - \frac{1211}{(T + 220.8)}$$

Where,  $T$  is in °C,  $p$  is in *torr*. What are the units of 6.9057 and 1211? Convert this equation so that  $p$  can be directly found in  $N/m^2$  using  $T$  in  $K$ .

- (b) A producer gas has the volumetric composition of CO<sub>2</sub>:4.4%, CO: 23%, O<sub>2</sub>: 2.6% and N<sub>2</sub>: 70%. Calculate the amount of air in m<sup>3</sup> required if 100 kmol of the producer gas is burned with 25% excess air. Assume the temperatures and pressures of both air and gas are 25 °C and 750 mm Hg. What will be the composition of the stack gas assuming complete combustion of CO? (20)

6. (a) Perform the following calculations and write the final results explaining with the rules of significant figures (10)

- (i)  $3.200 \times 45.67$                       (ii)  $-0.02 + 2.08 + 301$   
 (iii)  $200.2 / (0.120 \times 5.4)$         (iv)  $3564.25 + 45.5 + 0.45$   
 (v)  $21.0 - 9.5$

- (b) A flue gas contains CO<sub>2</sub>, CO and N<sub>2</sub>. Two engineers calculated the average molecular weight of this flue gas. One has used the correct molecular weight of N<sub>2</sub> and obtained the average molecular weight of flue gas as 30.08 while the other engineer has used a wrong molecular weight of N<sub>2</sub> as 14 and found the average molecular weight of the flue gas as 18.74. What is the composition of the flue gas? (15)

- (c) Define each term with an appropriate example: (10)  
 Recycle, Theoretical Air, Yield, Selectivity, Purge

7. (a) An open-end mercury manometer is connected to a low pressure pipeline that supplies a gas to a laboratory (See Fig Q7a). Because paint was spilled on the arm connected to the line during a laboratory renovation, it is impossible to see the level of the manometer fluid in this arm. During a period when the gas supply is connected to the line but there is no gas flow, a Bourdon gauge connected to the line downstream from the manometer gives a reading of 8.5 psig. The level of mercury in the open arm is 900 mm above the lowest part of the manometer.

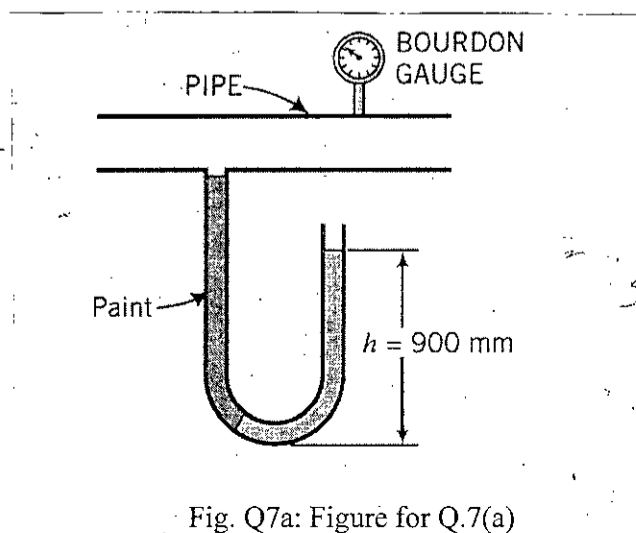


Fig. Q7a: Figure for Q.7(a)

Contd ..... P/4

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### Contd... Q. No. 7(a)

- (i) When the gas is not flowing, the pressure is same everywhere in the pipe. How high above the bottom of the manometer would the mercury be in the arm connected to the pipe? (10)
- (ii) When the gas is not flowing the mercury level in the visible arm falls by 20 mm. What is the gas pressure in psig at this moment? (10)
- (b) Spent Dye obtained from a soap manufacturer contains 9.6 wt% glycerol, 10.3% salt and the balance water. It is fed to a double effect evaporator at a rate of 5000 kg/h where it gets concentrated to 80% glycerol and 6% salt. Assume that 4.5% glycerol fed to the evaporator is lost with the water evaporated from the evaporator. Calculate all unknown streams with their compositions. (15)
8. (a) The oxidation of ethylene to produce ethylene oxide proceeds as: (20)
- $$2\text{C}_2\text{H}_4 + \text{O}_2 = 2\text{C}_2\text{H}_4\text{O}$$
- The feed to the reactor contains ethylene and air. It has a 10:1 mole ratio of oxygen to ethylene. The single pass conversion of ethylene is 25%. Ethylene is separated from the reactor effluents and recycled back to the feed stream. Calculate the flow rates and composition of all unknown streams including fresh feed, the recycle ratio and the overall conversion of ethylene.
- (b) To make strawberry jam, strawberries containing 12 wt% solids and 88% water are crushed and mixed with sugar in a ratio of 4:6. The mixture is heated to evaporate water. The residue (jam) contains 32% water by mass. Calculate the amount of strawberries needed to make 1 kg of jam. (15)
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**SECTION – A**

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Define Simple Harmonic Motion and write down its differential equation. Show that the vibration of spring-mass system is simple harmonic. (2 1/2 + 2 1/2 + 5)  
 (b) What do you mean by effective mass of a spring? Show that the effective mass of a spring of spring-mass system is one-third of its mass when the mass of the spring is not neglected. Hence deduce an expression for time period. (3+12)  
 (c) A block of mass 500 gm is fastened to spring whose spring constant 50 N/m. The block is pulled a distance 10 cm from its equilibrium position at  $x = 0$  and  $t = 0$  and then released. Calculate (i) time period (ii) amplitude (iii) maximum speed (iv) phase constant (v) write down its displacement equation. (10)
  
2. (a) What is a wave? Classify it and give an example of each type of wave. From the displacement equation of a wave derives its one dimensional differential equation. (2+6+6)  
 (b) State the principle of superposition. Use it to explain the formation of stationary waves in a medium and deduce an expression for this wave. What are nodes and antinodes? (3+6)  
 (c) The equation of a wave travelling is given by  $\psi = 0.06 \sin(4.0 \pi t + 2.0 \pi x)$  in M. K. S unit. Calculate (i) wavelength and wave speed. The wave is reflected back from a rigid support 3m away from the incident point (ii) Write down the equation of the reflected wave (iii) How many loops are formed within this length (iv) Deduce the equation of the stationary wave (v) Calculate the number of antinodes and strain at the position of antinode. (12)
  
3. (a) What are reverberation and reverberation time? State the assumptions of Sabine and obtain an expression for the reverberation time. (4+17)  
 (b) What are the acoustic requirements of a good auditorium? (6)  
 (c) Find the reverberation time of a room 10 m wide by 20 m long by 5 m high. The ceiling is acoustic, the walls are plaster, the floor is concrete and there are 40 people in the room. [Sound absorption coefficients are: acoustic ceiling = 0.60, plaster = 0.03, concrete = 0.02. Absorbing power of each person = 0.5 Sabine]. Velocity of sound = 340 m/sec. (8)

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4. (a) What do you mean by coherent sources of light? Mention three conditions for sustained interference of light. (8)
- (b) Using Newton's ring experiment, how can you determine the wavelength of light? Explain in details. (20)
- (c) During determination of the wavelength of light by the displacement method in a Fresnel's biprism experiment, the height/length between maximum and minimum position of interference pattern was found as 4.05 mm for a certain position of convex lens placed between the screen and biprism. In the second suitable position of the convex lens adjusted through the optical bench, the length of the interference pattern became 2.9 mm. If the fringe separation was found as 0.1719 mm and the distance between the source and the screen was 1.0 m. Calculate the wavelength of light used. (7)

**SECTION - B**

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What do you mean by diffraction of light? Write down the differences between interference and diffraction of light. (10)
- (b) What do you mean by dispersive power of grating? Obtain an expression to determine the dispersive power of grating. (16)
- (c) A light wave is incident on a surface of water of refractive index 1.33. If the reflected light is polarized, calculate the angle of polarization. Also determine the angle of incidence and angle of refraction. (9)
6. (a) What do you mean by plane of polarization and plane of vibration? What are polarizer and analyzer? (10)
- (b) On what basis, light can be treated as a transverse wave? Explain in details with suitable diagrams. (15)
- (c) Two polaroids are adjusted so as to obtain maximum intensity. Through what angle should one polaroid be rotate to reduce the intensity to (i) half and (ii) one fourth? (10)
7. (a) Describe the principle and construction of a platinum resistance thermometer. Explain how it works with the help of Callendar and Griffith's bridge. (17)
- (b) Write down the advantages and disadvantages of platinum resistance thermometer. (6)
- (c) The resistance of platinum resistance thermometer are 2.56, 3.56 and 6.78 ohms at 0 °C and the boiling point of Sulphur on the gas scale (444.6 °C). The thermometer when placed in an unknown temperature bath is found to have a resistance of 5.23 ohms. Calculate the temperature of the bath on the gas scale. (12)



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8. (a) State first law of thermodynamics. Calculate the work done in each operation of a Carnot cycle when the working substance is a perfect gas. **(15)**
- (b) Prove that the efficiency of all reversible engines working between the same two temperatures must be the same. **(8)**
- (c) A Carnot refrigerator takes heat from water at  $0\text{ }^{\circ}\text{C}$  and discards it to a room at  $27\text{ }^{\circ}\text{C}$ . 1 kg of water at  $0^{\circ}\text{C}$  is to be changed into ice at  $0^{\circ}\text{C}$ . **(12)**
- (i) How many calories of heat discarded to the room?
- (ii) What is the co-efficient of performance of the machine?
- Given latent heat of fusion of ice = 80 cal/gm.
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