L-I/T-2/CHE Date: 10/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-I/T-2 B. Sc. Engineering Examinations 2019-2020

Sub: CHE 111 (Elements of Chemical Engineering)

Full Marks: 180 Time: 2 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

A data booklet containing all relevant data is attached

SECTION-A

There are FOUR questions in this section. Answer any THREE. Each question carries 30 marks.

1. In a scientific article on measuring flows from pipes, the author calculated $q = 40.988$ m^3/s using the following formula:

$$q = C\,A_1\sqrt{\frac{2\,g\,V\,(p_1 - p_2)}{1 - \left(\frac{A_1}{A_2}\right)^2}}$$

Where, q = volumetric flow rate, m^3/s

C = dimensionless coefficient, 0.6

A_1 = area, 2 m^2

A_2 = area, 5 m^2

V =specific volume, 10^{-3} m^3/kg

p = pressure; $p_1 - p_2$ is 50 kPa

g = acceleration of gravity

2 is a dimensionless constant

Was the calculation of the author correct? Justify the reasons for your yes or no answer. In case of an incorrect answer by the author, what will be the correct formula and the correct answer?

2. An equimolar mixture of benzene and toluene is subjected to fractionation (distillation) to produce a distillate (overhead) product having the composition of 95 mol% benzene and the bottom product having a composition of 96 mol% toluene. The column is equipped with a condenser in which the vapour leaving the top of the distillation column is totally condensed. It was found that the vapour contains the 83% of the total feed to the column. A part of the condensate is recycled back to the column as reflux and the other part is removed as distillate product. The vapour, distillate and the reflux have the same composition. Determine the reflux ratio of the column, i.e., the quantity refluxed to the quantity distillate product.

3. A pyrolysis gas from rice husks is found to contain 6.4% CO_2, 0.1% O_2, 39% CO, 51.8% H_2, 0.6% CH_4, and the balance N_2. The pyrolysis gas entering a combustion chamber at 300K and 120 kPa is burned with 50% excess air. The flue gas leaves the combustion chamber at 400 K and 101.3 kPa. The 10% of the CO entering the combustion chamber remains unconverted. For a basis of one cubic meter of gas entering the combustion chamber, determine the quantity of air supplied to the combustion chamber in moles; composition of the flue gas leaving the combustion chamber and cubic meters of flue gas at STP (25 °C and 1 atm).

4. The fresh feed to an ammonia production process contains nitrogen and hydrogen in stoichiometric proportion, along with 1 mole% inert gas. The feed is combined with a recycle stream containing the same three species and the combined stream is fed to a reactor in which a single pass conversion of 25% is achieved. The reactor effluent flows to a condenser. A liquid stream containing essentially all of the ammonia formed in the reactor and a gas stream containing all the inert and the unreacted nitrogen and hydrogen leave the condenser. 1% of the gas stream leaving the condenser is removed as purge and the rest constitutes the recycle stream. Draw and completely label the flow chart of the process, find the overall conversion of nitrogen, and the composition of the combined feed to the reactor.

SECTION-B

There are FOUR questions in this section. Answer any THREE. The figures in the margin indicate full marks. Use the attached data booklet for any necessary data.

5. (a) Define the following terms with appropriate examples
i) state property ii) reference state iii) intensive property iv) extensive property v) system and system boundary. **(15)**

(b) A cylinder with a movable piston contains 4.0 liters of a gas at 30°C and 5.0 bar. The piston is slowly moved to compress the gas to 8.0 bar.

i) Considering the system to be the gas in the cylinder and neglecting ΔE_p, write and simplify the closed-system energy balance. Do not assume that the process is isothermal in this part.
ii) Suppose now that the process is carried out isothermally, and the compression work done on the gas equals 10 /L·bar. If the gas is ideal so that $\dot{U}$ is a function only of T, how much heat (in joules) is transferred to or from (state which) the surroundings? (Use the gas-constant table in the back of the book to determine the factor needed to convert L· bar to joules.)
iii) Suppose instead that the process is adiabatic and that $\dot{U}$ increases as T increases. Is the final system temperature greater than, equal to, or less than 30°C? (Briefly state your reasoning.)

(15)

6. (a) Lime (calcium oxide) is widely used in the production of cement, steel, medicines, insecticides, plant and animal food, soap, rubber, and many other familiar materials. It is usually produced by heating and decomposing limestone ($CaCO_3$), a cheap and abundant mineral, in a *calcination* process:

$$CaCO_3\,(s) \xrightarrow{heat} CaO(s) + CO_2\,(g)$$

Limestone at 25°C is fed to a continuous calcination reactor. The calcination is complete, and the products leave at 900°C. Taking 1 metric ton of limestone as a basis and elemental species [Ca(s), C(s), O (g)] at 25°C as references for enthalpy calculations, prepare and fill in an inlet–outlet enthalpy table and prove that the required heat transfer to the reactor is 2.7×10^6 kJ.

(15)

(b) A turbine discharges 200 kg/h of saturated steam at 12.0 bar absolute. It is desired to generate steam at 250°C and 10.0 bar by mixing the turbine discharge with a second stream of superheated steam of 300°C and 5.0 bar.

i) If 400 kg/h of the product steam is to be generated, how much heat must be added to the mixer?

ii) If instead the mixing is carried out adiabatically, at what rate is the product steam generated?

(15)

7. (a) Liquid water is fed to a boiler at 20°C and 10 bar and is converted at constant pressure to saturated steam. Use the steam tables to calculate $\Delta\widehat{H}$ (kJ/kg) for this process, and then calculate the heat input required to produce 15,000 m^3 /h of steam at the exiting conditions. Assume that the kinetic energy of the entering liquid is negligible and that the steam is discharged through a 12-cm ID pipe. **(18)**

(b) Define the terms (i) Heat of reaction (ii) Standard heat of reaction (iii) Standard heat of formation, and iv) Heat of combustion. **(12)**

8. Sulfur dioxide is oxidized to sulfur trioxide in a small pilot-plant reactor. SO_2 and 100% excess air are fed to the reactor at 400°C. The reaction proceeds to a 70% SO_2 conversion, and the products emerge from the reactor at 550°C. The production rate of SO_3 is 100 kg/min. The reactor is surrounded by a water jacket into which water at 25°C is fed.

i) Calculate the feed rates (standard cubic meters per second) of the SO_2 and air feed streams and the extent of reaction, $\dot{\xi}$ (kmol/s).

ii) Calculate the standard heat of the SO_2 oxidation reaction, $\Delta\widehat{H}_r^o$ (kJ/mol). Then, taking molecular species at 25°C as references, prepare and fill in an inlet–outlet enthalpy table and write an energy balance to calculate the heat (kW) that must be transferred from the reactor to the cooling water.

iii) Calculate the minimum flow rate of the cooling water if its temperature rise is to be kept below 15°C.

iv) Briefly state what would have been different in your calculations and results if you had taken elemental species as references in part (ii).

(30)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B.Sc Engineering Examinations January 2020

Subject: **Chem 131** (Physical Chemistry I)

Full Marks: 180 Time: 2 hours

Figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION and upload in the LMS system separately

Symbols used here bear usual meaning. Assume reasonable values for any missing data.

SECTION - A

(There are **FOUR** questions in the section. Answer any **THREE**)

1. (a) In case of a dissolution process for a solid in liquid, explain the following thermal correlation with a suitable molecular model: $\Delta H_1 = \Delta H_2 + \Delta H_3$ (where the symbols have the usual meaning). Also discuss the energetics of the above dissolution process with the help of a diagram. — 12+8 = **20**

   (b) To analyze the alcohol content of a sample, it needs 1.00 L of an aqueous 0.200 M $K_2Cr_2O_7$ solution. How much solid $K_2Cr_2O_7$ (molar mass = 294.2) must be weighed out to make this solution? — **10**

2. (a) Define mathematically and state the significance of the terms 'absorption co-efficient and Oswald solubility co-efficient'. Discuss the factors influencing the solubility of CO_2 in sea water. — 8+12 = **20**

   (b) The solubility of CO_2 in water at 25 °C and 1 atm is 0.034 mol/L. What is its solubility under atmospheric condition? (The partial pressure of CO_2 in air is 0.0003 atm). Assume that CO_2 obeys Henry's law. — **10**

3. (a) State the concept of colloidal system and colloidal medium with illustration. Propose an experimental technique to determine the particle size of the colloidal particles utilizing scattering of light. — 8+12 = **20**

   (b) Discuss the practical use of Tyndall effect and Brownian movement exhibited by the colloids. — **10**

4. Write notes on: — 15x2 = **30**

   i) Fractionating column as an advanced tool in industrial separation processes.

   ii) Formation and effects of acid rain.

Section B

(There are **FOUR** questions in the section. Answer any **THREE**)

5. a) Consider the following reaction: 10

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Explain the effect of pressure and addition of an inert gas on the equilibrium of the reaction.

b) What is thermodynamic equilibrium constant? Thermodynamic equilibrium constant is a measure of standard free energy change of a chemical reaction- explain. 12

c) The equilibrium constant K_p for the reaction, 8

$C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$ is 5.04×10^{17} at 25°C. Calculate ΔG°.

6. a) Explain the terms differential heat of solution and integral heat of solution. 10

b) Elucidate how the heat of reaction varies with temperature at constant pressure and constant volume. 12

c) Heat of formation of methane at constant pressure and at 298 K is −17.890 kcal. Calculate the heat of formation at constant volume. 8

7. a) Rationalize that, for a reversible process the entropy of the universe is zero. 10

b) How does entropy change with the variation of temperature and volume at constant pressure? 12

c) Calculate the entropy change involved in an isothermal reversible expansion of 2 moles of an ideal gas from a volume 5 L to a volume of 50 L at 303K. 8

8. a) Free energy is the total work obtainable from the system minus the pressure-volume work– explain 10

b) Explain how free energy changes with temperature and pressure. 12

c) Two moles of an ideal gas are allowed to expand isothermally and reversibly at 300K from a pressure of 1 atm to a pressure of 0.1 atm. What will be the change in Gibbs free energy? 8

L-1/T-2/ChE Date: 17/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2019-2020

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

Full Marks: 180 Time: 2 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. Evaluate the following integrals: (15+15)

   (a) $\int \frac{d\theta}{\sqrt{2-\tan\theta}}$

   (b) $\int \frac{dx}{(1+x^2)\sqrt{5+x^2}}$

2. (a) Find a reduction formula for $\int \sin^m x \cos nx\, dx$ and hence evaluate $\int \sin^5 x \cos 3x\, dx$. (15)

   (b) Evaluate: (15)

$$\lim_{n\to\infty}\left[\left(2+\frac{1}{n^2}\right)^{1/n^2}\left(2+\frac{4}{n^2}\right)^{2/n^2}\left(2+\frac{9}{n^2}\right)^{3/n^2}\cdots\cdots\cdots(3)^{1/n}\right]$$

3. (a) Using Gamma function evaluate: $\int_0^{\pi/2} \frac{d\varphi}{\sqrt{1-\frac{1}{2}\sin^2\varphi}}$. (15)

   (b) Evaluate the improper integral: $\int_0^{\infty} \frac{\ln(1+u^2)}{(1+u^2)} du$. (15)

4. (a) Find the area of the region bounded by y-axis, the lines y = a, y = 2a and the semi-cubical parabola $ay^2 = x^3$. (15)

   (b) Evaluate the volume of the solid generated by the revolving of the lemniscate $r^2 = a^2 \cos 2\theta$ about the line $\theta = \pi/2$. (15)

SECTION -B

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

5. (a) What is the condition for a differential equation to be exact? (15)

Determine whether the following differential equation is exact or not. If it is exact, solve it.

$$\left(2y \sin x \cos x - y + 2y^2 e^{xy^2}\right)dx - \left(x - \sin^2 x - 4xye^{xy^2}\right)dy = 0.$$

(b) What is Bernoulli's equation? Solve the following equation: (15)

$$x^2 y^{\frac{3}{2}} \frac{dy}{dx} - 2xy^{\frac{5}{2}} = 3y^{\frac{11}{2}}, \quad y(1) = \frac{1}{2}.$$

6. (a) When a cake is removed from an oven, its temperature is measured at 370^0F. Two minutes later its temperature is 300^0F. How long will it take to cool off to a room temperature of 70^0F ? (15)

(b) Solve the following differential equation by using variation of parameters $y'' - 4y' + 4y = (12x^2 - 6x)\, e^{2x}$. (15)

7. (a) Solve $y'' + y' = 0$ by considering x variable is absent. (15)

(b) Solve the following differential equation by converting it to constant coefficients: (15)

$$x^2 y'' + xy' + y = \ln x \ .$$

8. (a) For a spring-mass model, interpret and solve the following initial value problem (15)

$$0.5x'' + 2.5x' + 5x = 3\cos 2t$$

$$\text{with } x(0) = 1,\ x'(0) = -1.$$

(b) Solve the following differential equation (15)

$$(y')^2 - 3yy' + 2y^2 = 0$$

by the method of factorization operator.

L-1/T-2/ChE Date: 13/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

B. Sc. Engineering Examinations January 2020

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

Full Marks: 180 Time: 2 Hours

The figures in the margin indicate full marks. Symbols have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION-A

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

1. (a) Write down the key points on the validity of Gauss's theorem in electrostatics. Using Gauss's theorem, derive an expression for the electric field intensity at a point near a thin infinite plane sheet of charge density σ C/m^2. [20]

   (b) Two large parallel thin metallic plates are placed close to each other. The plates have surface charge densities of opposite signs and of magnitude 2.0×10^{-12} C/m^2. Calculate electric field intensity (i) in the outer region of the plates and (ii) in the interior region between the plates. [10]

2. (a) Show that the capacitance of a parallel plate capacitor with a dielectric slab of thickness $t < d$, where d is the separation between the parallel plates $C = \dfrac{k\varepsilon_o A}{t + k(d-t)}$, where the symbols have their usual meaning. [20]

   (b) A parallel plat capacitor has a capacitance of 100 μμF, a plate area of 100 cm^2, and a mica of dielectric constant, k = 5.4. At 50 V potential difference, calculate (a) the free charge on the plates, (b) electric field in the mica. [10]

3. (a) Discuss the property of self-inductance and mutual inductance in terms of flux linkages and their applications in the transformers. [15]

   (b) Briefly discuss the domain theory of ferromagnetism and explain the hysteresis loop of a ferromagnetic material. What is the significance of the area of the hysteresis loop? [15]

4. (a) Sketch [100], [110] and [111] crystal directions in a unit cell of a typical face centered cubic crystal. What is linear density of atoms? Compute and compare linear density values for these crystal directions for copper. Atomic radius of copper atom is 0.1278 nm. [15]

   (b) Sketch (100), (110) and (111) crystal planes in a unit cell of a typical body centered cubic crystal. What is planar density of atoms? Compute and compare planar density of atoms for these planes for α-Fe crystal. Atomic radius of α-Fe is 0.1243 nm. [15]

SECTION-B

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

5. (a) Distinguish between crystalline and amorphous solids. You are given tungsten and gold crystals. Discuss all possible differences from crystallographic point of view. [15]
(b) (i) What are the differences between orthorhombic and cubic crystal systems? (ii) Discuss about their possible space lattices. (iii) Draw the unit cells of their various space lattices. [15]

6. (a) What is X-ray diffraction? What information do you get from X-ray diffraction of a crystal? From this information how will you obtain lattice parameters of a unit cell? [20]
(b) Suppose you are given a solid whose crystal structure is face centered cubic, atomic weight is M_x and the atomic radius is R. From this information derive an expression for the density of this material. [10]

7. (a) Derive Lorentz transformation equation in special theory of relativity [20]
(b) Spacecraft A is moving at $0.95c$ with respect to the earth, where c is the speed of light. If spacecraft B is to pass A at a relative speed of $0.70c$ in the same direction, what speed must B have with respect to the earth? [10]

8. (a) Discuss the different experimental observations of photoelectric effect, which could not be explained by classical physics. [20]
(b) Light of wavelength 430 nm is incident on a nickel surface of work function 5 eV and a potassium surface of work function 2.3 eV. Calculate, if electrons are ejected, and if so, the maximum velocity of the ejected electrons in each case. (1 eV = 1.6×10^{-19} J, $h = 6.63\times10^{-34}$ J-s and $c = 3\times10^{8}$ m/s). [10]

L-1/T-2/ChE 20/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-I/T-II B.Sc. Engineering Examinations, January 2020

Sub: **HUM 125** (English)

Full Marks: 120 Time 2 Hours

The Figures in the right-hand margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

There are 4 page(s) in this question paper.

SECTION – A

There are **FOUR** questions in this section. Answer question No. 1 as compulsory and any **TWO** from the rest.

Figures in the brackets indicate the marks of the questions concerned

1. Answer **any one** of the following questions: (20)

   (a) How was the Loisel family affected by the incident of the loss of the diamond necklace?

   (b) 'The Bet' "shows two different perceptions of life – the life of worldly pursuits and the life of renunciation". Discuss.

2. (a) Explain with reference to the context **any one** of the following: (10)

   i. "Oh my poor Matilda! Mine were false. They were not worth over five hundred francs!"

   ii. "His reading suggested a man swimming in the sea among the wreckage of his ship ..."

   (b) Answer **any two** of the following questions: (10)

   i. What happened in the morning on which the lawyer left his prison?

   ii. In spite of being a charming young lady why was Mrs. Matilda Loisel so unhappy?

   iii. What impression do you get about Mrs. Sheridan as pictured in 'The Garden Party'?

3. Write a dialogue between two Chemical Engineering students about the management of chemical waste in Bangladesh. (20)

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

Men usually want to have their own way. They want to think and act as they like. No one, however, can have his own way all the time. A man cannot live in society without considering the interests of others as well as his own interests. 'Society' means a group of people with the same laws and the same way of life. People in society may make their own decisions, but these decisions ought not to be unjust or harmful to others. One man's decisions may so easily harm another person. For example, a motorist may be in a hurry to get to a friend's house. He sets out, driving at full speed like a competitor in a motor race. There are other vehicles and also pedestrians on the road. Suddenly there is a crash. There are screams and confusion. One careless motorist has struck another car. The collision has injured two of the passengers and killed the third. Too many road accidents happen through the thoughtlessness of selfish drivers. We have governments, the police and the law courts to prevent or to punish such criminal acts. But in addition, all men ought to observe certain rules of conduct. Every man ought to behave with consideration for other men. He ought not to steal, cheat or destroy the property of others. There is no place for this sort of behavior in a civilized society.

SECTION – B

There are **FOUR** questions in this section. Answer **Q. No. 5** and any **TWO** from the rest.

Figures in the brackets indicate the marks of the questions concerned

5. Read the following passage and answer the questions that follow: (5 × 4 = 20)

Too many parents these days can't say no. As a result, they find themselves raising 'children' who respond greedily to the advertisements aimed right at them. Even getting what they want doesn't satisfy some kids; they only want more. Now, a growing number of psychologists, educators and parents think it's time to stop the madness and start teaching kids about what's really important: values like hard work, contentment, honesty and compassion. The struggle to set limits has never been tougher and the stakes have never been higher. One recent study of adults who were overindulged as children, paints a discouraging picture of their future: when given too much too soon, they grow up to be adults who have difficulty coping with life's disappointments. They also have distorted sense of entitlement that gets in the way of success in the work place and in relationships.

Psychologists say that parents who overindulge their kids, set them up to be more vulnerable to future anxiety and depression. Today's parents themselves raised on values of thrift and self-sacrifice, grew up in a culture where 'no' was a household word. Today's kids want much more, partly because there is so much more to want. The oldest members of this generation were born in the late 1980s, just as PCs and video games were making their assault on the family room. They think of MP3 players and flat screen TV as essential utilities, and they have developed strategies to get them. One survey of teenagers found that when they crave for something new, most expect to ask nine times before their parents give in. By every measure, parents are shelling out record amounts. In the heat of this buying blitz, even parents who desperately need to say 'no' find themselves reaching for their credit cards.

Today's parents aren't equipped to deal with the problem. Many of them, raised in the 1960s and '70s, swore they'd act differently from their parents and have closer relationships with their own children. Many even wear the same designer clothes as their kids and listen to the same music. And they work more hours; at the end of a long week. It's tempting to buy peace with 'yes' and not mar precious family time with conflict. Anxiety about future is another factor. How do well intentioned parents say 'no' to all the sports gear and arts and language lessons

they believe will help their kids thrive in an increasingly competitive world? Experts agree: too much love won't spoil a child. Too few limits will.

What parents need to find, is a balance between the advantages of an affluent society and the critical life lessons that come from waiting, saving and working hard to achieve goals. That search for balance has to start early. Children need limits on their behaviour because they feel better and more secure when they live within a secured structure. Older children learn self-control by watching how others, especially parents act. Learning how to overcome challenges is essential to becoming a successful adult. Few parents ask kids to do chores. They think their kids are already overburdened by social and academic pressures. Every individual can be of service to others, and life has meaning beyond one's own immediate happiness. That means parents eager to teach values have to take a long, hard look at their own.

Questions:

(i) Why do parents and teachers want their children to learn values?

(ii) What happens when children are given too much immediately after demand?

(iii) Do you think that today's children are more demanding? Elucidate.

(iv) Why is it necessary to set the limits on the behavior of the children?

6. Write an adjustment letter to a firm in reply to a complaint of poor services and defective products. (20)

7. Write a short essay on **any one** of the following: (20)
   (i) The Effect of Social Media on the Youth
   (ii) Contribution of Technology to Education

8. Briefly show the main differences between a report and a literary work. Why has the importance of reports increased in our times? (20)