

KATHMANDU UNIVERSITY
End Semester Examination
February/March, 2018

Marks Scored:

Level : B.E.

Year : III

Course : CHEG 301

Semester: I

Exam.Roll No.:

Time: 30 mins.

F.M. : 10

Registration No.:

Date FEB 26 2018

SECTION "A"

[20 Q.×0.5=10 marks]

Attempt ALL questions.

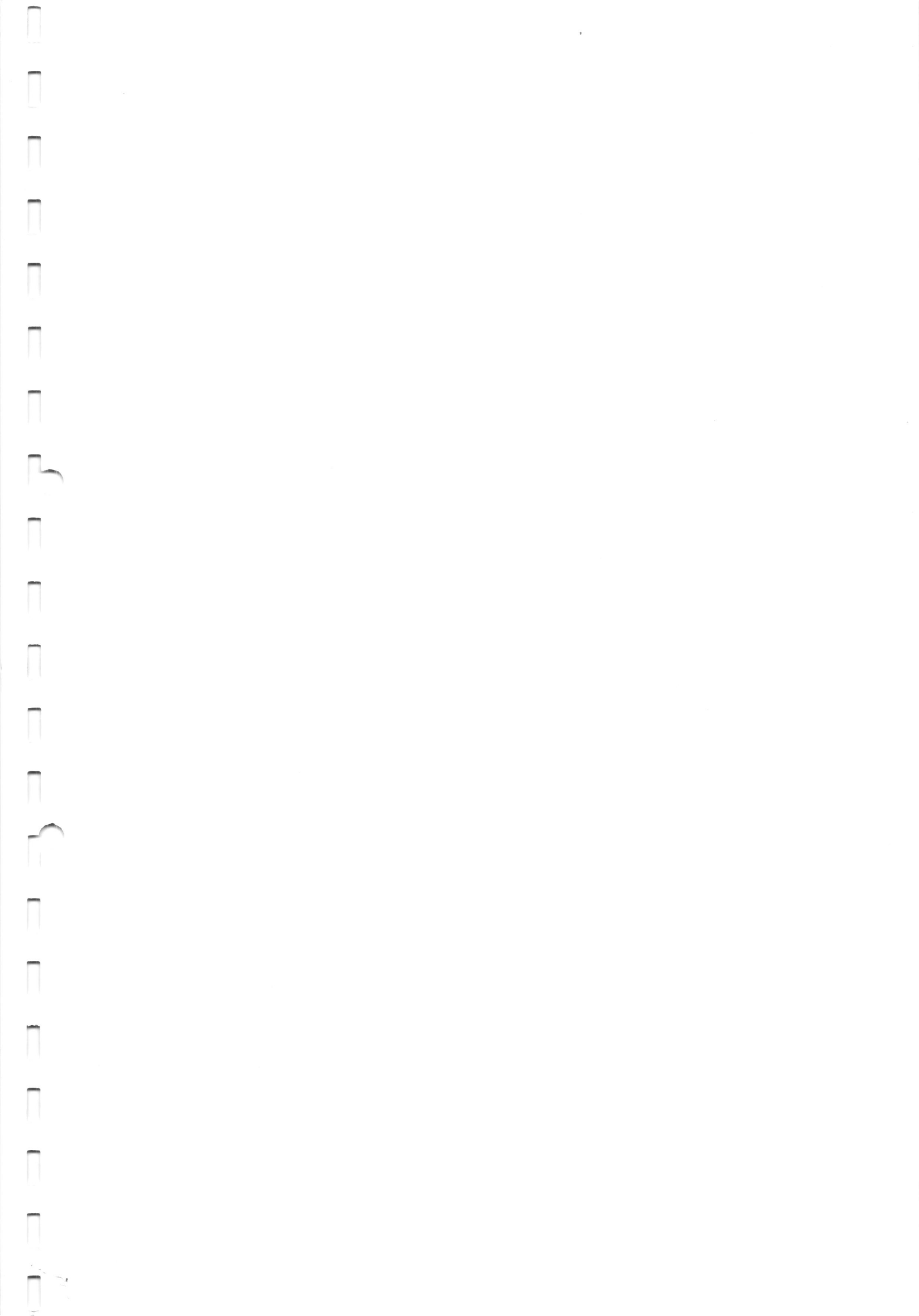
Tick the most appropriate answer.

- The unit of the rate of a reaction is
a. $\text{mol L}^{-1} \text{s}^{-1}$ b. mol L^{-1} c. $\text{L mol}^{-1} \text{s}^{-1}$ d. L mol^{-1}
- All reactants are charged to a reactor at once and no materials are fed to or taken out of the reactor during reaction. The reactor is
a. CSTR b. PFR c. PBR d. batch reactor
- The rate of reaction for reactant A is defined by
a. $\frac{dC_A}{dt}$ where C_A is the concentration of reactant A and t is reaction time.
b. $\frac{1}{V} \frac{dN_A}{dt}$ where V is the reaction volume and N_A is the number of moles of reactant A.
c. $\frac{dF_A}{dt}$ where F_A is the molar flow rate of reactant A.
d. $\frac{d(v \cdot C_A)}{dt}$ where v is the volumetric flow rate.
- The statement that is false is
a. The reaction rate depends on type of catalyst.
b. The reaction rate depends on species concentration.
c. The reaction rate depends on type of reactor.
d. The reaction rate depends on system pressure.
- In a CSTR, the molar flow rate of reactant A was 1 mol/s and the volumetric flow rate was 0.5 L/s at the reactor inlet. The concentration of A at the reactor inlet is
a. 0.5 mol/L b. 1.0 mol/L c. 1.5 mol/L d. 2.0 mol/L
- The conversion of a reaction is defined by the number of moles of limiting reactant that have reacted per
a. mole of excess reactant. b. mole of desired product.
c. mole of limiting reactant. d. mole of undesired product.
- If a CSTR is replaced with a PFR of same volume for a reaction rate represented by $-r_A = \frac{1}{1-X_A}$ where r_A is the reaction rate of reactant A and X_A is the conversion of A,
a. the conversion of A would increase.
b. the conversion of A would decrease.
c. the conversion of A would increase up to a conversion of 0.5 and decrease thereafter.
d. the conversion of A would decrease up to a conversion of 0.5 and increase thereafter.
- The volumetric flow rate that is used to determine the space time in a continuous flow reactor is the
a. volumetric flow rate at the reactor inlet.
b. volumetric flow rate at the standard condition.
c. volumetric flow rate at 60°F.
d. volumetric flow rate 75°F.

9. For a reaction order of n , the unit of the rate constant can be expressed as
 a. concentration/time
 b. (concentration) ^{n} /time
 c. (concentration) ^{$(1-n)$} /time
 d. (concentration/time) ^{n}
10. The activation energy of a reaction is
 a. the difference in potential energy between reactants and products.
 b. the difference in potential energy between reactants and the transition state molecule.
 c. the difference between potential energy and kinetic energy of reactants.
 d. the difference in potential energy between products and the transition state molecule.
11. The relationship between rate constant and activation energy can be represented by
 a. Clapeyron equation
 b. Antoine equation.
 c. Soave-Redlich-Kwong (SRK) equation.
 d. Arrhenius equation.
12. The burning of a coal in a rotary kiln can be represented by C (solid) + O_2 (gas) \rightarrow CO_2 (gas). Assuming that the reaction is isothermal and isobaric, the volumetric flow rate of the gas should
 a. decrease with the conversion of the coal.
 b. increase with the conversion of the coal.
 c. remain constant with the conversion of the coal.
 d. decrease in the initial stage and increase in the later stage.
13. The Damkohler number of a reaction
 a. is the rate of reaction at entrance divided by the entering flow rate of A.
 b. decreases with increasing conversion.
 c. can be expressed for all reactions as a function of space time and rate constant.
 d. indicates how fast a reaction can approach the equilibrium state.
14. The equation used most to calculate pressure drop in a packed column is
 a. Bernoulli equation.
 b. Ergun equation.
 c. Antoine equation.
 d. Arrhenius equation.
15. Which reactor is desirable to increase the conversion of a thermodynamically limited reaction?
 a. semi-batch reactor
 b. membrane reactor.
 c. fluidized bed reactor
 d. plug flow reactor.
16. The concentration of reactant A was measured with time in a batch reactor. The preferred method of determining the reaction order with respect to A is
 a. the differential method.
 b. the integral method.
 c. the method of initial rates.
 d. the method of half-lives.
17. The reactor that is used most commonly for the study of kinetics for gas-solid reactions is
 a. batch reactor.
 b. semi-batch reactor.
 c. CSTR.
 d. differential reactor.
18. Choose a statement that is false in describing the differential reactor.
 a. The reactor consists of a tube containing a very small amount of catalyst.
 b. The reaction rate can be considered to be spatially uniform within the bed.
 c. With reaction time, usually reactant concentrations are measured rather than product concentrations.
 d. The reaction can be considered to be isothermal.

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19. The overall yield of a reaction in a tubular reactor is
- the ratio of exit molar flow rate of desired product to exit molar flow rate of undesired product.
 - the ratio of exit molar flow rate of desired product to exit molar flow rate of the key reactant that have been consumed.
 - the ratio of exit molar flow rate of undesired product to exit molar flow rate of desired product.
 - the ratio of exit molar flow rate of undesired product to exit molar flow rate of the key reactant that have been consumed.
20. For a multiple reaction of $A \rightarrow D$ (desired product) and $A \rightarrow U$ (undesired product), the production rate of D, $r_D = k_D C_A$ and the production rate of U, $r_U = k_U C_A^{1/2}$ where C_A and C_B are the concentrations of A and B, respectively. The preferred reactor to maximize the selectivity of the desired product is
- batch reactor.
 - CSTR.
 - PFR with recycle.
 - fluidized bed reactor.



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SECTION "B"

Attempt *ALL* questions.

1. A gas-phase reaction represented by $A + 2B \rightarrow 2C + 3D$ was carried out in a PBR, 10 cm in diameter and 1 m in length. The true density of the catalyst particles loaded in the reactor was 3.0 g/cm^3 and the bulk density was 1.5 g/cm^3 .

1.1 Calculate the mass of the catalyst.

1.2 Calculate the void fraction in the reactor.

1.3 When the reaction rate of component A is $-1 \frac{\text{mol}}{\text{L}\cdot\text{s}}$, determine the reaction rate for component D.

1.4 Convert a reaction rate of $1 \frac{\text{mol}}{\text{L}\cdot\text{s}}$ into the reaction rate in $\frac{\text{mol}}{\text{g}\cdot\text{s}}$.

[1+1+1+1]

2. Nitrogen oxide that is used for production of nitric acid was manufactured using an isothermal PFR at 5 atm and 200°C through a reaction represented by $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$. Air was used as a source for oxygen. The molar fraction of ammonia in the feed to the reactor was 0.1. Determine the concentration of NO at the conversion of 0.5.

[4]

3. The elementary gas-phase reaction $A = B + 2C$ is carried out in a membrane reactor with no pressure drop. Product B flows out of the sides of the reactor with the transport coefficient of $k_C = 0.08 \text{ s}^{-1}$. The rate constant of the forward reaction at 50°C is 10^{-4} min^{-1} and the activation energy is 85 kJ/mol. Reactant A enters the reactor at 5 atm and 100°C and at a molar flow rate of 2.5 mol/min. The concentration equilibrium constant is $0.025 \text{ mol}^2 \text{ dm}^{-6}$. Write the program for Polymath to calculate the reactor volume to achieve 80% conversion. All necessary constants should be specified in the program.

[6]

4. An irreversible reaction, $A \rightarrow B + C$ was carried out in a batch reactor. The concentrations of reactant A with reaction time were measured to be as follows:

Time, min	0.0	2.0	4.0	6.0
C_A , mol/L	2.00	1.31	0.95	0.73

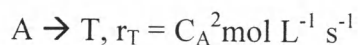
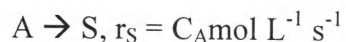
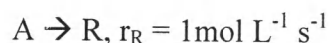
Determine the reaction order with respect to A.

$$r_{A0} = \frac{-3C_{A0} + 4C_{A1} - C_{A2}}{2\Delta t}$$

$$r_{A3} = \frac{C_{A1} - 4C_{A2} + 3C_{A3}}{2\Delta t}$$

[5]

5. For the decomposition of A, the following three reactions occur in parallel.



S is the desired product, and R and T are undesired products. $C_{A0} = 5 \text{ mol/L}$, $C_{R0} = C_{S0} = C_{T0} = 0 \text{ mol/L}$. Find the maximum concentration of the desired product, S in a CSTR.

[5]

SECTION "C"

Attempt ALL questions.

6. A liquid-phase reaction represented by $A \rightarrow B$ was carried out in a continuous reactor. The reactant A is pure, the concentration is 5 mol/L , and the volumetric flow rate is 10 L/min . The reaction rate of A, $-r_A = kC_A$ where $k = 0.1/\text{min}$. and C_A represents the molar concentration of A. Determine the volume of a CSTR to achieve a conversion (X_A) of 0.8. [4]

OR

A reaction represented by $A \rightarrow B$ was carried out in a batch reactor. The reaction rate of A can be expressed as $-r_A = kC_A^2$ ($k = 0.1 \frac{\text{L}}{\text{mol}\cdot\text{s}}$). The initial concentration of A in the reactor was at 1 mol/L . Calculate the time it would take for the concentration of A in the reactor to fall down to one fifth of the initial concentration.

7. A reversible gas-phase reaction represented by $A=2B$ was carried out in a PFR at 400 K and 10 atm . The reactant fed into the reactor was pure A and the concentration equilibrium constant is known to be 0.25 L/mol . Calculate the conversion of A and the concentrations at equilibrium. [4]

OR

The reaction of $\text{N}_2\text{O}_4(\text{g}) = 2\text{NO}_2(\text{g})$ was carried out at 25°C in a 100 L batch reactor. Initially the pressure was at 2 atm and there existed N_2O_4 only. Calculate the partial pressure of NO_2 when 50% of N_2O_4 was consumed.

8. An elementary liquid-phase reaction represented by $A \rightarrow R$ was carried out in an isothermal CSTR with the recycle ratio at 2. The final conversion of A was measured to be 0.5. Calculate the conversion in the absence of the recycle. [4]

OR

The rate equation of a reaction, $A \rightarrow R$ is represented by

$$-r_A = 0.1 C_A \text{ (mol/l} \cdot \text{hr)}$$

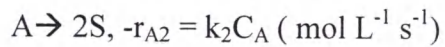
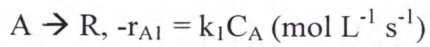
At the recycle ratio of 2, $C_{A0} = 1 \text{ mol/L}$, and at the space time of 5 h, calculate the final concentration of A (C_{Af}).

9. Two parallel irreversible liquid-phase reactions, $A \rightarrow R$, $A \rightarrow S$ were carried out in a PFR with pure A as feed at 10 mol/L. Calculate the molar concentration of the product stream leaving the reactor when the conversion of A is 90%. [4]

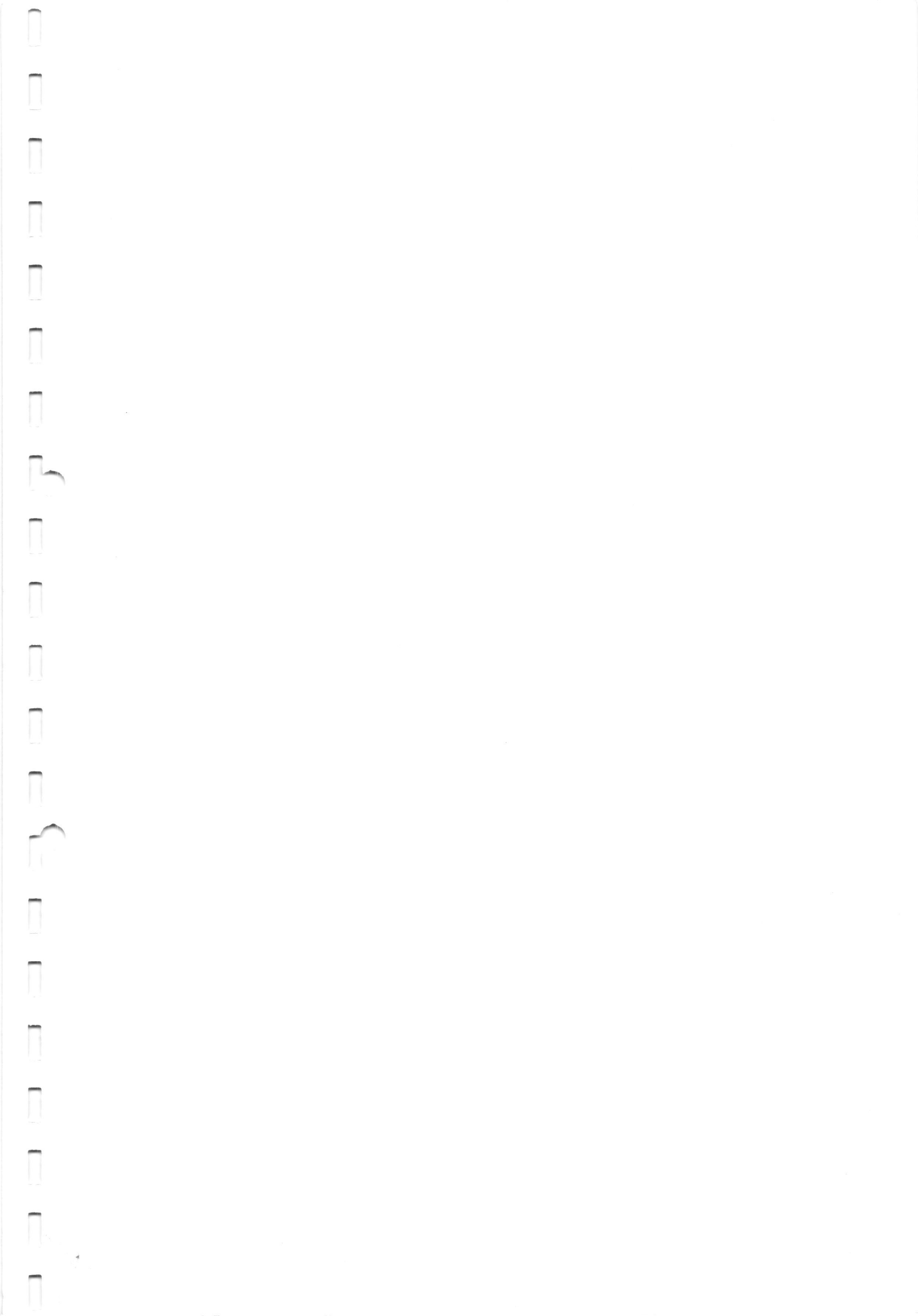
$$\frac{dC_R}{dt} = 100 C_A, \quad \frac{dC_S}{dt} = 1.0 C_A^2$$

OR

The following two reactions were carried out in a constant-volume batch reactor.



$k_1 = k_2 = 0.1 \text{ s}^{-1}$. Assuming that initially no S and R were present, calculate the conversion of A at $t = 10 \text{ s}$.



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SECTION "A"

[10 Q × 1=10 marks]

Choose and tick the most appropriate answer.

- Which one of the following surfaces has the highest albedo?
[a] Dry sand [b] Sea water [c] Fresh snow [d] Green forest
- The atmospheric ozone absorbs essentially all the radiation below a wavelength of
[a] 240 nm [b] 255 nm [c] 295 nm [d] 400 nm
- Most of the weather activities take place in
[a] ionosphere [b] mesosphere [c] troposphere [d] stratosphere
- Burning and decay of biomass are the main anthropogenic sources of
[a] methane [b] nitrous oxide
[c] carbon dioxide [d] chlorofluorocarbon
- The atomic oxygen (O) is formed through the photodissociation of molecular oxygen (O₂) by light of wavelength shorter than
[a] 175 nm in the 100 km region [b] 175 nm between 20 and 26 km region
[c] 295 nm in the 100 km region [d] 295 nm between 20 and 26 km region
- The tide producing force is due to the sun and the moon; and the proportion is about
[a] 10% due to the sun and 90% due to the moon
[b] 30% due to the sun and 70% due to the moon
[c] 50% due to the sun and 50% due to the moon
[d] 70% due to the sun and 30% due to the moon
- To maintain the ideal conditions inside the core of the nuclear reactor, appropriate measurement must be taken through
[a] moderator [b] fissionable materials (fuels)
[c] neutron reflector [d] control rods and core cooling
- The intensity of a sound from a jet plane is 10^{-3} W/m². The intensity level of this sound in decibel is
[a] 30 [b] 60 [c] 90 [d] 100
- A plume occurs under stable condition, vertical dispersion is restricted so that the pollutants disperse at the stack height horizontally. Such a plume is named as
[a] looping plume [b] fanning plume [c] coning plume [d] lofting plume
- One of the remote sensing satellite SPOT is French acronym for
[a] system for earth satellite [b] system for earth monitoring
[c] system for earth resources [d] system for earth observation

SECTION "B"
[10 Q. × 1 = 10 marks]

Fill in the blanks.

11. The level at which a parcel of air adiabatically lifted from near the surface first reaches saturation is called
12. The average thickness of the troposphere is approximately km in the middle latitudes.
13. Polar winters are dark, consisting of three months without sun. The lack of sunlight contributes to a decrease in temperature hovering around°C.
14. On October 11, the solar declination δ has a value of about (degrees).
15. The wind speed is reduced to one-fourth of its original speed. Power available remains the same if the diameter of the rotor is increased by times.
16. The temperature at the base of the crust is about 1000°C and in average, heat is flowing outward the earth's surface at a rate of about W/m².
17. Nuclear waste recycling is a new waste disposal method in which the fission products are separated into different streams using
18. If the sound pressure increases from 0.02 Pa to 0.2 Pa, then the sound pressure level increases by dB.
19. Thermal conductivity is associated with the transport of
20. One of the instruments on Upper Atmosphere Research Satellite (UARS) performs HALOE which means

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SECTION "C"

[5 Q. × 4 = 20 marks]

1. Show that the dry adiabatic lapse rate is higher than the saturated adiabatic lapse rate.
2. Explain the possible impacts of global warming.
OR
Discuss the ozone formation and ozone depletion process in the atmosphere.
3. Define the terms direct, diffuse and global solar radiation. Discuss the variation of extraterrestrial solar radiation.
OR
Discuss the construction and working of hydrogen/oxygen fuel cell.
4. Explain the different methods of disposal of nuclear waste.
5. What do you mean by radiation inversion? Explain the lofting plume and fumigating plume with well labeled diagrams.
OR
Define the term remote sensing (RS). Discuss the principle, types and system overview of remote sensing.

SECTION "D"

[5 Q. × 7 = 35 marks]

6. Define the term albedo. Discuss the global energy balance and derive all the necessary relations to explain it in detail.
7. Define global warming potential (GWP). Discuss global warming potential with pre-industrial concentration, recent concentration, atmospheric life and GWP values of some of the greenhouse gases.
OR
What do you mean by ozone hole? Explain the Antarctic ozone hole. Also, explain why no Arctic ozone hole has been detected over the north pole in the spring.
8. Discuss the energy from fossil fuels and estimate the amount of energy release during combustion of natural oil (petroleum) and hence find out the energy content in it in kJ/gm.
(Bond energy in kJ/mole for C–C, C–H, O–H, O=O and C=O are 347, 410, 460, 494 and 799 respectively)
OR
What is the basic principle used in energy from tides (tidal energy). Estimate the average power in watts.
9. Write down the environmental impacts of nuclear energy and explain the nuclear hazards and safety measures.
10. Define the terms sound intensity and sound intensity level. Derive the expressions for sound insulation and effective air insulation in case of sound leaks.
OR
Differentiate between RADAR and LIDAR. Discuss the LIDAR measurements of stratospheric ozone and location of atmospheric pollution.

