





GATE 2014: General Instructions during Examination


1. Total duration of the GATE examination is **180** minutes.
2. The clock will be set at the server. The countdown timer at the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You need not terminate the examination or submit your paper.
3. Any useful data required for your paper can be viewed by clicking on the **Useful Common Data** button that appears on the screen.
4. Use the scribble pad provided to you for any rough work. Submit the scribble pad at the end of the examination.
5. You are allowed to use a non-programmable type calculator, however, sharing of calculators is not allowed.
6. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:

 You have not visited the question yet.

 You have not answered the question.

 You have answered the question.

 You have NOT answered the question, but have marked the question for review.

 You have answered the question, but marked it for review.

The **Marked for Review** status for a question simply indicates that you would like to look at that question again. *If a question is answered, but marked for review, then the answer will be considered for evaluation unless the status is modified by the candidate.*

Navigating to a Question :

7. To answer a question, do the following:
 - a. Click on the question number in the Question Palette to go to that question directly.
 - b. Select an answer for a multiple choice type question by clicking on the bubble placed before the 4 choices, namely A, B, C and D. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
 - c. Click on **Save & Next** to save your answer for the current question and then go to the next question.
 - d. Click on **Mark for Review & Next** to save your answer for the current question and also mark it for review, and then go to the next question.

Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on a question number without saving the answer to the previous question.

You can view all the questions by clicking on the **Question Paper** button. This feature is provided, so that if you want you can just see the entire question paper at a glance.

Answering a Question :

8. Procedure for answering a multiple choice (MCQ) type question:
 - a. Choose one answer from the 4 options (A,B,C,D) given below the question, click on the bubble placed before the chosen option.
 - b. To deselect your chosen answer, click on the bubble of the chosen option again or click on the **Clear Response** button.
 - c. To change your chosen answer, click on the bubble of another option.
 - d. To save your answer, you MUST click on the **Save & Next** button.
9. Procedure for answering a numerical answer type question:
 - a. To enter a number as your answer, use the virtual numerical keypad.
 - b. A fraction (e.g. -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point. As many as four decimal points, e.g. 12.5435 or 0.003 or -932.6711 or 12.82 can be entered.
 - c. To clear your answer, click on the **Clear Response** button.
 - d. To save your answer, you MUST click on the **Save & Next** button
10. To mark a question for review, click on the **Mark for Review & Next** button. *If an answer is selected (for MCQ) or entered (for numerical answer type) for a question that is **Marked for Review**, that answer will be considered in the evaluation unless the status is modified by the candidate.*
11. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.
12. Note that **ONLY** Questions for which answers are *saved* or *marked for review after answering* will be considered for evaluation.

Choosing a Section :

13. Sections in this question paper are displayed on the top bar of the screen. Questions in a Section can be viewed by clicking on the name of that Section. The Section you are currently viewing will be highlighted.
14. A checkbox is displayed for every optional Section, if any, in the Question Paper. To select the optional Section for answering, click on the checkbox for that Section.
15. If the checkbox for an optional Section is not selected, the **Save & Next** button and the **Mark for Review & Next** button will NOT be enabled for that Section. You will

only be able to see questions in this Section, but you will not be able to answer questions in the Section.

16. After clicking the **Save & Next** button for the last question in a Section, you will automatically be taken to the first question of the next Section in sequence.
17. You can move the mouse cursor over the name of a Section to view the answering status for that Section.

Changing the Optional Section :

18. After answering the chosen optional Section, partially or completely, you can change the optional Section by selecting the checkbox for a new Section that you want to attempt. A warning message will appear along with a table showing the number of questions answered in each of the previously chosen optional Sections and a checkbox against each of these Sections. Click on a checkbox against a Section that you want to reset and then click on the **RESET** button. Note that RESETTING a Section will DELETE all the answers for questions in that Section. Hence, if you think that you may want to select this Section again later, you will have to note down your answers for questions in that Section. If you do not want to reset the Section and want to continue answering the previously chosen optional Section, then click on the **BACK** button.
19. If you deselect the checkbox for an optional Section in the top bar, the following warning message will appear: "Deselecting the checkbox will DELETE all the answers for questions in this Section. Do you want to deselect this Section?" If you want to deselect, click on the **RESET** button. If you do not want to deselect, click on the **BACK** button.
20. You can shuffle between different Sections or change the optional Sections any number of times.

GATE 2014 Examination

CH: Chemical Engineering

Duration: 180 minutes

Maximum Marks: 100

Read the following instructions carefully.

1. To login, enter your Registration Number and password provided to you. Kindly go through the various symbols used in the test and understand their meaning before you start the examination.
2. Once you login and after the start of the examination, you can view all the questions in the question paper, by clicking on the **View All Questions** button in the screen.
3. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory.
The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.
The subject specific GATE paper section consists of **55** questions, out of which question numbers 1 to 25 are of 1-mark each, while question numbers 26 to 55 are of 2-mark each.
4. Depending upon the GATE paper, there may be useful common data that may be required for answering the questions. If the paper has such useful data, the same can be viewed by clicking on the **Useful Common Data** button that appears at the top, right hand side of the screen.
5. The computer allotted to you at the examination center runs specialized software that permits only one answer to be selected for multiple-choice questions using a mouse and to enter a suitable number for the numerical answer type questions using the virtual keyboard and mouse.
6. Your answers shall be updated and saved on a server periodically and also at the end of the examination. The examination will **stop automatically** at the end of **180 minutes**.
7. In each paper a candidate can answer a total of 65 questions carrying 100 marks.
8. The question paper may consist of questions of **multiple choice type (MCQ)** and **numerical answer type**.
9. Multiple choice type questions will have four choices against A, B, C, D, out of which only **ONE** is the correct answer. The candidate has to choose the correct answer by clicking on the bubble (○) placed before the choice.
10. For numerical answer type questions, each question will have a numerical answer and there will not be any choices. **For these questions, the answer should be entered** by using the virtual keyboard that appears on the monitor and the mouse.
11. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of $\frac{1}{3}$ marks for a 1-mark question and $\frac{2}{3}$ marks for a 2-mark question.
12. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.
13. Non-programmable type Calculator is allowed. Charts, graph sheets, and mathematical tables are **NOT** allowed in the Examination Hall. You must use the Scribble pad provided to you at the examination centre for all your rough work. The Scribble Pad has to be returned at the end of the examination.

Declaration by the candidate:

“I have read and understood all the above instructions. I have also read and understood clearly the instructions given on the admit card and shall follow the same. I also understand that in case I am found to violate any of these instructions, my candidature is liable to be cancelled. I also confirm that at the start of the examination all the computer hardware allotted to me are in proper working condition”.

Q. 1 – Q. 5 carry one mark each.

- Q.1 A student is required to demonstrate a high level of comprehension of the subject, especially in the social sciences.

The word closest in meaning to comprehension is

- (A) understanding (B) meaning (C) concentration (D) stability

- Q.2 Choose the most appropriate word from the options given below to complete the following sentence.

One of his biggest _____ was his ability to forgive.

- (A) vice (B) virtues (C) choices (D) strength

- Q.3 Rajan was not happy that Sajan decided to do the project on his own. On observing his unhappiness, Sajan explained to Rajan that he preferred to work independently.

Which one of the statements below is logically valid and can be inferred from the above sentences?

- (A) Rajan has decided to work only in a group.
 (B) Rajan and Sajan were formed into a group against their wishes.
 (C) Sajan had decided to give in to Rajan's request to work with him.
 (D) Rajan had believed that Sajan and he would be working together.

- Q.4 If $y = 5x^2 + 3$, then the tangent at $x = 0, y = 3$

- (A) passes through $x = 0, y = 0$ (B) has a slope of +1
 (C) is parallel to the x -axis (D) has a slope of -1

- Q.5 A foundry has a fixed daily cost of Rs 50,000 whenever it operates and a variable cost of Rs 800Q, where Q is the daily production in tonnes. What is the cost of production in Rs per tonne for a daily production of 100 tonnes?

Q. 6 – Q. 10 carry two marks each.

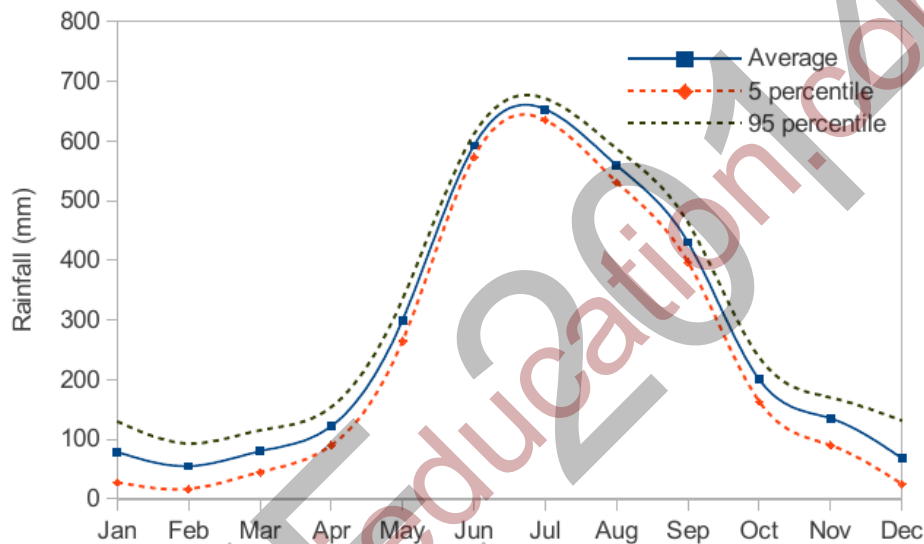
- Q.6 Find the odd one in the following group: ALRVX, EPVZB, ITZDF, OYEIK

- (A) ALRVX (B) EPVZB (C) ITZDF (D) OYEIK

- Q.7 Anuj, Bhola, Chandan, Dilip, Eswar and Faisal live on different floors in a six-storeyed building (the ground floor is numbered 1, the floor above it 2, and so on). Anuj lives on an even-numbered floor. Bhola does not live on an odd numbered floor. Chandan does not live on any of the floors below Faisal's floor. Dilip does not live on floor number 2. Eswar does not live on a floor immediately above or immediately below Bhola. Faisal lives three floors above Dilip. Which of the following floor-person combinations is correct?

| | Anuj | Bhola | Chandan | Dilip | Eswar | Faisal |
|-----|------|-------|---------|-------|-------|--------|
| (A) | 6 | 2 | 5 | 1 | 3 | 4 |
| (B) | 2 | 6 | 5 | 1 | 3 | 4 |
| (C) | 4 | 2 | 6 | 3 | 1 | 5 |
| (D) | 2 | 4 | 6 | 1 | 3 | 5 |

- Q.8 The smallest angle of a triangle is equal to two thirds of the smallest angle of a quadrilateral. The ratio between the angles of the quadrilateral is 3:4:5:6. The largest angle of the triangle is twice its smallest angle. What is the sum, in degrees, of the second largest angle of the triangle and the largest angle of the quadrilateral?
- Q.9 One percent of the people of country X are taller than 6 ft. Two percent of the people of country Y are taller than 6 ft. There are thrice as many people in country X as in country Y. Taking both countries together, what is the percentage of people taller than 6 ft?
- (A) 3.0 (B) 2.5 (C) 1.5 (D) 1.25
- Q.10 The monthly rainfall chart based on 50 years of rainfall in Agra is shown in the following figure. Which of the following are true? (k percentile is the value such that k percent of the data fall below that value)



- (i) On average, it rains more in July than in December
(ii) Every year, the amount of rainfall in August is more than that in January
(iii) July rainfall can be estimated with better confidence than February rainfall
(iv) In August, there is at least 500 mm of rainfall
- (A) (i) and (ii) (B) (i) and (iii)
(C) (ii) and (iii) (D) (iii) and (iv)

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 Gradient of a scalar variable is always

- (A) a vector (B) a scalar (C) a dot product (D) zero

Q.2 For the time domain function $f(t) = t^2$, which **ONE** of the following is the Laplace transform of

$$\int_0^t f(t) dt ?$$

- (A) $\frac{3}{s^4}$ (B) $\frac{1}{4s^2}$ (C) $\frac{2}{s^3}$ (D) $\frac{2}{s^4}$

Q.3 If $f^*(x)$ is the complex conjugate of $f(x) = \cos(x) + i \sin(x)$, then for real a and b ,

$$\int_a^b f^*(x) f(x) dx \text{ is ALWAYS}$$

- (A) positive (B) negative (C) real (D) imaginary

Q.4 If $f(x)$ is a real and continuous function of x , the Taylor series expansion of $f(x)$ about its minima will **NEVER** have a term containing

- (A) first derivative (B) second derivative (C) third derivative (D) any higher derivative

Q.5 From the following list, identify the properties which are equal in both vapour and liquid phases at equilibrium

P. Density

Q. Temperature

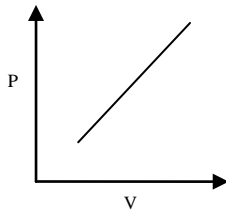
R. Chemical potential

S. Enthalpy

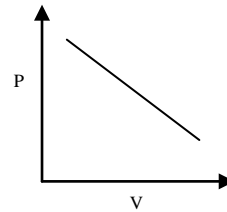
- (A) P and Q only (B) Q and R only (C) R and S only (D) P and S only

Q.6 In a closed system, the isentropic expansion of an ideal gas with constant specific heats is represented by

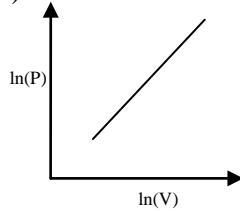
(A)



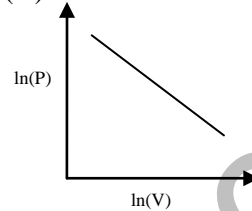
(B)



(C)



(D)



Q.7 Match the following

Group 1

Group 2

P. $\left(\frac{\partial G}{\partial n_i}\right)_{T,P,n_{j \neq i}}$

I. Arrhenius equation

Q. $\left(\frac{\partial G}{\partial n_i}\right)_{S,V,n_{j \neq i}}$

II. Reaction equilibrium constant

R. $\exp\left(\frac{-\Delta G_{reaction}^0}{RT}\right)$

III. Chemical potential

S. $\sum (n_i d\mu_i)_{T,P} = 0$

IV. Gibbs-Duhem equation

(A) Q—III, R—I, S—II

(B) Q—III, R—II, S—IV

(C) P—III, R—II, S—IV

(D) P—III, R—IV, S—I

Q.8 In order to achieve the same conversion under identical reaction conditions and feed flow rate for a non-autocatalytic reaction of positive order, the volume of an ideal CSTR is

- (A) always greater than that of an ideal PFR
 (B) always smaller than that of an ideal PFR
 (C) same as that of an ideal PFR
 (D) smaller than that of an ideal PFR only for first order reaction

Q.9 Integral of the time-weighted absolute error (ITAE) is expressed as

(A) $\int_0^{\infty} \frac{|\varepsilon(t)|}{t^2} dt$ (B) $\int_0^{\infty} \frac{|\varepsilon(t)|}{t} dt$ (C) $\int_0^{\infty} t |\varepsilon(t)| dt$ (D) $\int_0^{\infty} t^2 |\varepsilon(t)| dt$

Q.10 A unit **IMPULSE** response of a first order system with time constant τ and steady state gain K_p is given by

(A) $\frac{1}{K_p \tau} e^{t/\tau}$ (B) $K_p e^{-t/\tau}$ (C) $\tau K_p e^{-t/\tau}$ (D) $\frac{K_p}{\tau} e^{-t/\tau}$

Q.11 In a completely opaque medium, if 50% of the incident monochromatic radiation is absorbed, then which of the following statements are **CORRECT**?

- P. 50% of the incident radiation is reflected
 Q. 25% of the incident radiation is reflected
 R. 25% of the incident radiation is transmitted
 S. No incident radiation is transmitted

- (A) P and S only (B) Q and R only (C) P and Q only (D) R and S only

Q.12 In case of a pressure driven laminar flow of a Newtonian fluid of viscosity (μ) through a horizontal circular pipe, the velocity of the fluid is proportional to

(A) μ (B) $\mu^{0.5}$ (C) μ^{-1} (D) $\mu^{-0.5}$

Q.13 Which of the following statements are **CORRECT**?

P. For a rheopectic fluid, the apparent viscosity increases with time under a constant applied shear stress

Q. For a pseudoplastic fluid, the apparent viscosity decreases with time under a constant applied shear stress

R. For a Bingham plastic, the apparent viscosity increases exponentially with the deformation rate

S. For a dilatant fluid, the apparent viscosity increases with increasing deformation rate

(A) P and Q only (B) Q and R only (C) R and S only (D) P and S only

Q.14 Assume that an ordinary mercury-in-glass thermometer follows first order dynamics with a time constant of 10 s. It is at a steady state temperature of 0°C . At time $t = 0$, the thermometer is suddenly immersed in a constant temperature bath at 100°C . The time required (in s) for the thermometer to read 95°C , approximately is

(A) 60 (B) 40 (C) 30 (D) 20

Q.15 Packed towers are preferred for gas-liquid mass transfer operations with foaming liquids because

(A) in packed towers, high liquid to gas ratios are best handled

(B) in packed towers, continuous contact of gas and liquid takes place

(C) packed towers are packed with random packings

(D) in packed towers, the gas is not bubbled through the liquid pool

Q.16 A spherical storage vessel is quarter-filled with toluene. The diameter of the vent at the top of the vessel is $1/20^{\text{th}}$ of the diameter of the vessel. Under the steady state condition, the diffusive flux of toluene is maximum at

(A) the surface of the liquid

(B) the mid-plane of the vessel

(C) the vent

(D) a distance 20 times the diameter of the vent away from the vent

- Q.17 In order to produce fine solid particles between 5 and 10 μm , the appropriate size reducing equipment is
- (A) fluid energy mill (B) hammer mill
(C) jaw crusher (D) smooth roll crusher
- Q.18 Slurries are most conveniently pumped by a
- (A) syringe pump (B) diaphragm pump
(C) vacuum pump (D) gear pump
- Q.19 Assuming the mass transfer coefficients in the gas and the liquid phases are comparable, the absorption of CO_2 from reformer gas ($\text{CO}_2 + \text{H}_2$) into an aqueous solution of diethanolamine is controlled by
- (A) gas phase resistance (B) liquid phase resistance
(C) both gas and liquid phase resistances (D) composition of the reformer gas
- Q.20 Which **ONE** of the following statements is **CORRECT** for the surface renewal theory?
- (A) Mass transfer takes place at steady state
(B) Mass transfer takes place at unsteady state
(C) Contact time is same for all the liquid elements
(D) Mass transfer depends only on the film resistance
- Q.21 Steam economy of a multiple effect evaporator system is defined as
- (A) kilogram of steam used per hour
(B) kilogram of steam consumed in all the effects for each kilogram of steam fed
(C) kilogram of steam used in all the effects for each kilogram of water vaporized per hour
(D) kilogram of water vaporized from all the effects for each kilogram of steam fed to the first effect
- Q.22 Decomposition efficiency (η_D) of an electrolytic cell used for producing NaOH is defined as
- (A) $\eta_D = (\text{grams of NaOH produced} / \text{grams of NaCl decomposed}) \times 100$
(B) $\eta_D = (\text{grams of NaOH produced} / \text{grams of NaCl charged}) \times 100$
(C) $\eta_D = (\text{gram equivalents of NaOH produced} / \text{gram equivalents of NaCl charged}) \times 100$
(D) $\eta_D = (\text{theoretical current to produce one gram equivalent} / \text{actual current to produce one gram equivalent}) \times 100$

Q.23 The vessel dispersion number for an ideal CSTR is

- (A) -1 (B) 0 (C) 1 (D) ∞

Q.24 Catalytic cracking is

- (A) a hydrogen addition process
(B) a carbon rejection process
(C) an exothermic process
(D) a coking process

Q.25 Which **ONE** of the following statements is **CORRECT**?

- (A) The major components of biodiesel are triglycerides
(B) Biodiesel is essentially a mixture of ethyl esters
(C) Biodiesel is highly aromatic
(D) Biodiesel has a very low aniline point

Q. 26 – Q. 55 carry two marks each.

Q.26 Consider the following differential equation

$$\frac{dy}{dx} = x + \ln(y) ; \quad y = 2 \text{ at } x = 0$$

The solution of this equation at $x = 0.4$ using Euler method with a step size of $h = 0.2$ is _____

Q.27 The integrating factor for the differential equation

$$\frac{dy}{dx} - \frac{y}{1+x} = (1+x) \quad \text{is}$$

- (A) $\frac{1}{1+x}$ (B) $(1+x)$ (C) $x(1+x)$ (D) $\frac{x}{1+x}$

Q.28 The differential equation $\frac{d^2y}{dx^2} + x^2 \frac{dy}{dx} + x^3 y = e^x$ is a

- (A) non-linear differential equation of first degree
- (B) linear differential equation of first degree
- (C) linear differential equation of second degree
- (D) non-linear differential equation of second degree

Q.29 Consider the following two normal distributions

$$f_1(x) = \exp(-\pi x^2)$$

$$f_2(x) = \frac{1}{2\pi} \exp\left\{-\frac{1}{4\pi}(x^2 + 2x + 1)\right\}$$

If μ and σ denote the mean and standard deviation, respectively, then

- (A) $\mu_1 < \mu_2$ and $\sigma_1^2 < \sigma_2^2$
- (B) $\mu_1 < \mu_2$ and $\sigma_1^2 > \sigma_2^2$
- (C) $\mu_1 > \mu_2$ and $\sigma_1^2 < \sigma_2^2$
- (D) $\mu_1 > \mu_2$ and $\sigma_1^2 > \sigma_2^2$

Q.30 In rolling of two fair dice, the outcome of an experiment is considered to be the sum of the numbers appearing on the dice. The probability is highest for the outcome of _____

Q.31 A spherical ball of benzoic acid (diameter = 1.5 cm) is submerged in a pool of still water. The solubility and diffusivity of benzoic acid in water are 0.03 kmol/m^3 and $1.25 \times 10^{-9} \text{ m}^2/\text{s}$ respectively. Sherwood number is given as $Sh = 2.0 + 0.6 Re^{0.5} Sc^{0.33}$. The initial rate of dissolution (in kmol/s) of benzoic acid approximately is

- (A) 3.54×10^{-11}
- (B) 3.54×10^{-12}
- (C) 3.54×10^{-13}
- (D) 3.54×10^{-14}

Q.32 A wet solid of 100 kg is dried from a moisture content of 40 wt% to 10 wt%. The critical moisture content is 15 wt% and the equilibrium moisture content is negligible. All moisture contents are on dry basis. The falling rate is considered to be linear. It takes 5 hours to dry the material in the constant rate period. The duration (in hours) of the falling rate period is _____

Q.33 A brick wall of 20 cm thickness has thermal conductivity of $0.7 \text{ W m}^{-1} \text{ K}^{-1}$. An insulation of thermal conductivity $0.2 \text{ W m}^{-1} \text{ K}^{-1}$ is to be applied on one side of the wall, so that the heat transfer through the wall is reduced by 75%. The same temperature difference is maintained across the wall before and after applying the insulation. The required thickness (in cm) of the insulation is _____

Q.34 An oil with a flow rate of 1000 kg/h is to be cooled using water in a double-pipe counter-flow heat exchanger from a temperature of 70°C to 40°C . Water enters the exchanger at 25°C and leaves at 40°C . The specific heats of oil and water are $2 \text{ kJ kg}^{-1} \text{ K}^{-1}$ and $4.2 \text{ kJ kg}^{-1} \text{ K}^{-1}$, respectively. The overall heat transfer coefficient is $0.2 \text{ kW m}^{-2} \text{ K}^{-1}$. The minimum heat exchanger area (in m^2) required for this operation is _____

Q.35 Which **ONE** of the following is **CORRECT** for an ideal gas in a closed system?

(A) $\left(\frac{\partial U}{\partial V}\right)_S V = nR\left(\frac{\partial U}{\partial S}\right)_V$ (B) $-\left(\frac{\partial H}{\partial P}\right)_S P = nR\left(\frac{\partial H}{\partial S}\right)_P$

(C) $\left(\frac{\partial U}{\partial V}\right)_S V = nR\left(\frac{\partial H}{\partial S}\right)_P$ (D) $\left(\frac{\partial H}{\partial P}\right)_S P = nR\left(\frac{\partial U}{\partial S}\right)_V$

Q.36 A binary distillation column is operating with a mixed feed containing 20 mol% vapour. If the feed quality is changed to 80 mol% vapour, the change in the slope of the q -line is _____

Q.37 A homogeneous reaction ($R \rightarrow P$) occurs in a batch reactor. The conversion of the reactant R is 67% after 10 minutes and 80% after 20 minutes. The rate equation for this reaction is

(A) $-r_R = k$ (B) $-r_R = k C_R^2$

(C) $-r_R = k C_R^3$ (D) $-r_R = k C_R^{0.5}$

Q.38 A vapour phase catalytic reaction ($Q + R \rightarrow S$) follows Rideal mechanism (R and S are not adsorbed). Initially, the mixture contains only the reactants in equimolar ratio. The surface reaction step is rate controlling. With constants a and b , the initial rate of reaction ($-r_o$) in terms of total pressure (P_T) is given by

$$(A) -r_o = \frac{aP_T}{1 + bP_T}$$

$$(B) -r_o = \frac{aP_T}{1 + bP_T^2}$$

$$(C) -r_o = \frac{aP_T^2}{1 + bP_T}$$

$$(D) -r_o = \frac{aP_T^2}{(1 + bP_T)^2}$$

Q.39 An incompressible fluid is flowing through a contraction section of length L and has a 1-D (x -direction) steady state velocity distribution, $u = u_0 \left(1 + \frac{2x}{L}\right)$. If $u_0 = 2$ m/s and $L = 3$ m, the convective acceleration (in m/s^2) of the fluid at L is _____

Q.40 Match the following

Group 1

- P. Tank in series model
- Q. Liquid-liquid extraction
- R. Optimum temperature progression
- S. Thiele modulus

Group 2

- I. Non-isothermal reaction
- II. Mixer-settler
- III. PFR with axial mixing
- IV. Solid catalyzed reaction

(A) P–II, Q–IV, R–I, S–III

(B) P–I, Q–II, R–III, S–IV

(C) P–III, Q–I, R–II, S–IV

(D) P–III, Q–II, R–I, S–IV

Q.41 Two elemental gases (A and B) are reacting to form a liquid (C) in a steady state process as per the reaction $A + B \rightarrow C$. The single-pass conversion of the reaction is only 20% and hence recycle is used. The product is separated completely in pure form. The fresh feed has 49 mol% of A and B each along with 2 mol% impurities. The maximum allowable impurities in the recycle stream is 20 mol%. The amount of purge stream (in moles) per 100 moles of the fresh feed is _____

- Q.42 Carbon monoxide (CO) is burnt in presence of 200% excess pure oxygen and the flame temperature achieved is 2298 K. The inlet streams are at 25 °C. The standard heat of formation (at 25 °C) of CO and CO₂ are -110 kJ mol^{-1} and -390 kJ mol^{-1} , respectively. The heat capacities (in $\text{J mol}^{-1} \text{ K}^{-1}$) of the components are

$$C_{p_{O_2}} = 25 + 14 \times 10^{-3} T$$

$$C_{p_{CO_2}} = 25 + 42 \times 10^{-3} T$$

where, T is the temperature in K. The heat loss (in kJ) per mole of CO burnt is _____

- Q.43 A cash flow of Rs. 12,000 per year is received at the end of each year (uniform periodic payment) for 7 consecutive years. The rate of interest is 9% per year compounded annually. The present worth (in Rs.) of such cash flow at time zero is _____

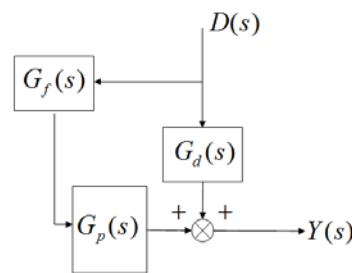
- Q.44 A polymer plant with a production capacity of 10,000 tons per year has an overall yield of 70%, on mass basis (kg of product per kg of raw material). The raw material costs Rs. 50,000 per ton. A process modification is proposed to increase the overall yield to 75% with an investment of Rs. 12.5 crore. In how many years can the invested amount be recovered with the additional profit?

- Q.45 A step change of magnitude 2 is introduced into a system having the following transfer function

$$G(s) = \frac{2}{s^2 + 2s + 4}$$

The percent overshoot is _____

Q.46 Given below is a simplified block diagram of a feedforward control system.



The transfer function of the process is $G_p = \frac{5}{s+1}$ and the disturbance transfer function is $G_d = \frac{1}{s^2 + 2s + 1}$. The transfer function of the **PERFECT** feedforward controller, $G_f(s)$ is

- (A) $\frac{-5}{(s+1)^3}$ (B) $\frac{-5}{(s+1)}$ (C) $\frac{-1}{5(s+1)}$ (D) $-5(s+1)$

Q.47 The bottom face of a horizontal slab of thickness 6 mm is maintained at 300 °C. The top face is exposed to a flowing gas at 30 °C. The thermal conductivity of the slab is 1.5 W m⁻¹ K⁻¹ and the convective heat transfer coefficient is 30 W m² K⁻¹. At steady state, the temperature (in °C) of the top face is _____

Q.48 In a steady incompressible flow, the velocity distribution is given by $\vec{V} = 3x\hat{i} - Py\hat{j} + 5z\hat{k}$, where, V is in m/s and x , y , and z are in m. In order to satisfy the mass conservation, the value of the constant P (in s⁻¹) is _____

Q.49 Match the following

Group 1

- P. Turbulence
Q. NPSH
R. Ergun equation
S. Rotameter
T. Power number

Group 2

- I. Reciprocating pump
II. Packed bed
III. Fluctuating velocity
IV. Impeller
V. Vena contracta

(A) P–III, R–II, T–IV

(B) Q–V, R–II, S–III

(C) P–III, R–IV, T–II

(D) Q–III, S–V, T–IV

Q.50 In a steady and incompressible flow of a fluid (density = 1.25 kg m^{-3}), the difference between stagnation and static pressures at the same location in the flow is 30 mm of mercury (density = 13600 kg m^{-3}). Considering gravitational acceleration as 10 m s^{-2} , the fluid speed (in m s^{-1}) is _____

Q.51 Consider a binary liquid mixture at equilibrium with its vapour at 25°C .

Antoine equation for this system is given as $\log_{10} p_i^{sat} = A - \frac{B}{t + C}$ where t is in $^\circ \text{C}$ and p in Torr.

The Antoine constants (A , B , and C) for the system are given in the following table.

| Component | A | B | C |
|-----------|-----|------|-----|
| 1 | 7.0 | 1210 | 230 |
| 2 | 6.5 | 1206 | 223 |

The vapour phase is assumed to be ideal and the activity coefficients (γ_i) for the non-ideal liquid phase are given by

$$\ln(\gamma_1) = x_2^2[2 - 0.6x_1]$$

$$\ln(\gamma_2) = x_1^2[1.7 + 0.6x_2]$$

If the mole fraction of component 1 in liquid phase (x_1) is 0.11, then the mole fraction of component 1 in vapour phase (y_1) is _____

Q.52 A process with transfer function, $G_p = \frac{2}{s-1}$ is to be controlled by a feedback proportional controller with a gain K_c . If the transfer functions of all other elements in the control loop are unity, then which **ONE** of the following conditions produces a stable closed loop response?

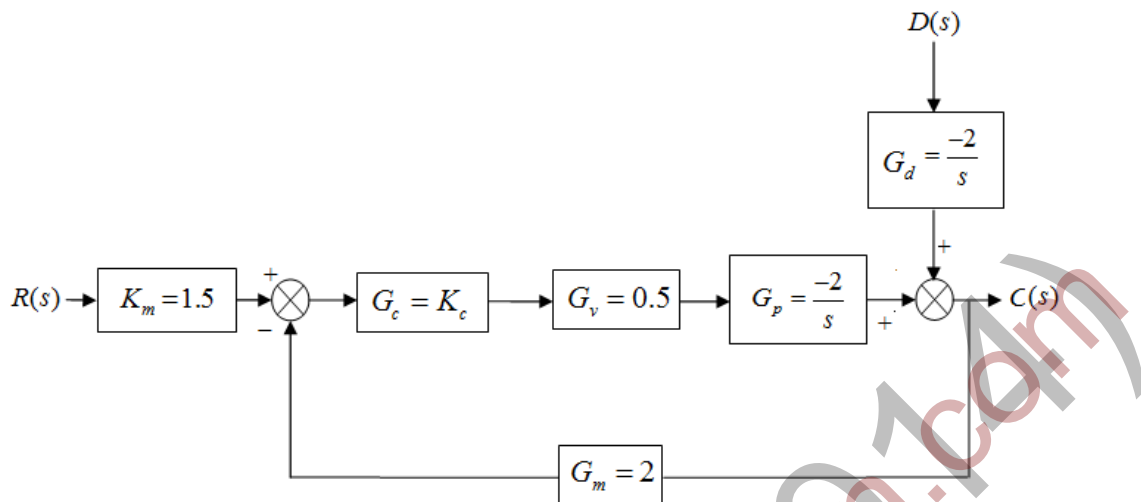
(A) $K_c = 0.25$

(B) $0 < K_c < 0.25$

(C) $0.25 < K_c < 0.5$

(D) $K_c > 0.5$

Q.53 Consider the following block diagram for a closed-loop feedback control system



A proportional controller is being used with $K_c = -4$. If a step change in disturbance of magnitude 2 affects the system, then the value of the offset is _____

Q.54 Determine the correctness or otherwise of the following Assertion [a] and Reason [r].

Assertion: Significant combustion of coke takes place only if it is heated at higher temperature in presence of air.

Reason: $C + O_2 \rightarrow CO_2$ is an exothermic reaction.

- (A) Both [a] and [r] are true and [r] is the correct reason for [a]
- (B) Both [a] and [r] are true but [r] is not the correct reason for [a]
- (C) [a] is correct but [r] is false
- (D) Both [a] and [r] are false

Q.55 Match the raw materials of Groups 1 and 2 with the final products of Group 3

Group 1

P₁: Ethylene
P₂: Propylene
P₃: Adipic acid
P₄: Terephthalic acid

Group 2

Q₁: Ammonia
Q₂: 1-Butene
Q₃: Ethylene glycol
Q₄: Hexamethylene diamine

Group 3

R₁: Synthetic fibre
R₂: Nylon 66
R₃: LLDPE
R₄: Acrylonitrile

- (A) P₁+Q₂→R₃; P₂+Q₁→R₄; P₃+Q₄→R₂; P₄+Q₃→R₁
(B) P₁+Q₁→R₃; P₂+Q₃→R₁; P₃+Q₄→R₄; P₄+Q₂→R₂
(C) P₁+Q₂→R₂; P₂+Q₃→R₁; P₃+Q₄→R₃; P₄+Q₁→R₄
(D) P₁+Q₁→R₄; P₂+Q₂→R₃; P₃+Q₄→R₂; P₄+Q₃→R₁

END OF THE QUESTION PAPER