Technical Abilities (Chemical): 100 MCQs

- Target Exam: RRB Junior Engineer (RRB JE)
- Study Notes Prepared for: Entri App Users

Here is a comprehensive 100-question Multiple Choice Practice Set covering core Chemical Engineering topics, including Thermodynamics, Fluid Mechanics, Heat & Mass Transfer, Reaction Engineering, Process Control, and Plant Design.

Section 1: Chemical Engineering Thermodynamics (Q1–Q18)

Q1. According to the First Law of Thermodynamics, for a closed system undergoing a cycle, the net work done is equal to the:

A) Net heat transferred

B) Internal energy change

C) Enthalpy change

D) Entropy change

Answer: A

Q2. The condition for thermodynamic equilibrium in a closed system at constant temperature and pressure is the minimization of:

A) Helmholtz free energy (A)

B) Gibbs free energy (G)

C) Internal energy (U)

D) Enthalpy (H)

Answer: B

Q3. For an ideal gas undergoing an isothermal expansion, the change in internal energy (ΔU) is:

A) Positive

B) Negative

C) Zero

D) Dependent on pressure

Answer: C

Q4. Fugacity has the same units as:

A) Temperature

B) Pressure

C) Density

D) Molar volume

Answer: B

Q5. For an ideal gas mixture, the fugacity coefficient (ϕ_i) of component i is:

A) 0

B) 0.5

C) 1.0

D) Infinite

Answer: C

Q6. Raoult's Law for vapor-liquid equilibrium (VLE) assumes:

A) Ideal liquid phase and ideal gas phase

B) Non-ideal liquid phase and non-ideal gas phase

C) High pressure system

D) Azeotropic mixture

Answer: A

Q7. At an azeotropic composition of a binary mixture:

A) Liquid composition equals vapor composition ($x_i = y_i$)

B) Boiling point is maximum only

C) Components can be easily separated by simple distillation

D) Relative volatility (α_{ij}) is infinity

Answer: A

Q8. The Clapeyron equation relates the slope of the phase boundary line (dP/dT) to:

A) $\Delta H/(T\Delta V)$

B) $\Delta U/(T\Delta P)$

C) $\Delta G/\Delta S$

D) $\Delta V/(T\Delta H)$

Answer: A

Q9. The Joule-Thomson coefficient (μ_{JT}) is defined as:

A) $(\partial T/\partial P)_H$

B) $(\partial P/\partial T)_H$

C) $(\partial H/\partial P)_T$

D) $(\partial T/\partial V)_P$

Answer: A

Q10. An ideal refrigeration cycle based on the reverse Carnot cycle has a Coefficient of Performance (COP) equal to:

A) $T_L/(T_H - T_L)$

B) $(T_H - T_L)/T_L$

C) $T_H/(T_H - T_L)$

D) $(T_H - T_L)/T_H$

Answer: A

Q11. The Lewis-Randall rule states that the fugacity of component i in an ideal solution is proportional to its:

A) Mole fraction in the mixture and pure species fugacity

B) Partial pressure

C) Critical pressure

D) Activity coefficient

Answer: A

Q12. The Gibbs-Duhem equation at constant temperature and pressure relates the changes in:

A) Chemical potentials of components in a phase

B) Heat capacities

C) Compressibility factors

D) Enthalpies of mixing

Answer: A

Q13. In a real fluid, the residual enthalpy (H^R) is the difference between real enthalpy and:

A) Ideal gas enthalpy at the same T and P

B) Saturated liquid enthalpy

C) Critical enthalpy

D) Enthalpy at absolute zero

Answer: A

Q14. The residual property M^R approaches zero as pressure approaches:

A) Critical pressure

B) Infinite pressure

C) Zero

D) 100 bar

Answer: C

Q15. The activity coefficient (γ_i) of a component in an ideal solution is equal to:

A) 0

B) 1

C) Infinity

D) Mole fraction

Answer: B

Q16. For an endothermic chemical reaction, increasing temperature shifts the equilibrium constant (K):

A) Upward (increases K)

B) Downward (decreases K)

C) No change

D) Drops to zero

Answer: A

Q17. Partial molar property of a pure species is equal to its:

A) Total property

B) Molar property

C) Residual property

D) Excess property

Answer: B

Q18. The compressibility factor (Z) for an ideal gas is:

A) 0

B) 1

C) > 1

D) < 1

Answer: B

Section 2: Fluid Mechanics (Q19–Q35)

Q19. A fluid whose shear stress is directly proportional to the velocity gradient is called a:

A) Newtonian fluid

B) Bingham plastic

C) Pseudoplastic fluid

D) Dilatant fluid

Answer: A

Q20. Paint and ketchup are classic examples of non-Newtonian fluids that exhibit:

A) Dilatant behavior

B) Shear-thinning (Pseudoplastic) behavior

C) Newtonian behavior

D) Bingham plastic behavior

Answer: B

Q21. The Reynolds number (Re) represents the ratio of:

A) Inertial forces to viscous forces

B) Viscous forces to gravity forces

C) Buoyancy forces to viscous forces

D) Pressure forces to inertial forces

Answer: A

Q22. For fully developed flow in a circular pipe, laminar flow corresponds to Re less than:

A) 500

B) 2100

C) 4000

D) 10000

Answer: B

Q23. In fully developed laminar flow through a pipe, the velocity profile is:

A) Flat / Uniform

B) Parabolic

C) Linear

D) Hyperbolic

Answer: B

Q24. The maximum velocity in fully developed laminar pipe flow is equal to how many times the average velocity?

A) 1.25

B) 1.5

C) 2.0

D) 2.5

Answer: C

Q25. Bernoulli's equation is derived assuming the fluid is:

A) Incompressible, non-viscous, and steady flow

B) Compressible, viscous, and unsteady flow

C) Viscous and turbulent

D) Rotational and non-ideal

Answer: A

Q26. The Hagen-Poiseuille equation calculates pressure drop for:

A) Turbulent pipe flow

B) Laminar pipe flow

C) Boundary layer flow over a flat plate

D) Compressible nozzle flow

Answer: B

Q27. Fanning friction factor (f) for fully developed laminar pipe flow is:

A) $16/Re$

B) $64/Re$

C) $0.079/Re^{0.25}$

D) $0.316/Re$

Answer: A

Q28. A Venturimeter is used to measure:

A) Fluid pressure

B) Fluid velocity at a single point

C) Volumetric flow rate

D) Fluid viscosity

Answer: C

Q29. A Pitot tube measures:

A) Average velocity

B) Local dynamic / stagnation pressure and velocity

C) Volumetric flow rate

D) Fluid density

Answer: B

Q30. Net Positive Suction Head (NPSH) available must be greater than NPSH required to prevent:

A) Priming

B) Cavitation

C) Water hammer

D) Choking

Answer: B

Q31. The drag coefficient (C_D) for spherical particles in Stokes' law regime ($Re < 0.1$) is:

A) $24/Re$

B) $16/Re$

C) 0.44

D) 1.0

Answer: A

Q32. Minimum fluidization velocity of a packed bed depends directly on:

A) Particle size and density difference

B) Pipe diameter

C) Length of pump suction line

D) Impeller blade width

Answer: A

Q33. Which pump is self-priming and suitable for handling highly viscous fluids at high pressures?

A) Centrifugal pump

B) Positive displacement pump (e.g., Reciprocating / Gear pump)

C) Axial flow pump

D) Ejector

Answer: B

Q34. The boundary layer thickness over a flat plate in laminar flow increases with distance x from the leading edge proportional to:

A) $x^{0.5}$

B) $x^{1.0}$

C) $x^{2.0}$

D) $1/x$

Answer: A

Q35. The power number (N_P) in agitated vessels for turbulent regime becomes:

A) Inversely proportional to Re

B) Constant

C) Proportional to Re^2

D) Zero

Answer: B

Section 3: Heat Transfer (Q36–Q52)

Q36. Fourier's law governs heat transfer by:

A) Convection

B) Conduction

C) Radiation

D) Evaporation

Answer: B

Q37. The thermal conductivity of gases generally:

A) Increases with increasing temperature

B) Decreases with increasing temperature

C) Remains constant with temperature

D) Depends only on pressure

Answer: A

Q38. The Prandtl number (Pr) is defined as the ratio of:

A) Momentum diffusivity to thermal diffusivity (ν/α)

B) Thermal diffusivity to momentum diffusivity

C) Inertial force to thermal force

D) Grashof number to Reynolds number

Answer: A

Q39. Overall heat transfer coefficient (U) is related to individual film coefficients (h_i, h_o) by:

A) Sum of individual coefficients

B) Sum of thermal resistances ($1/U = 1/h_i + R_{wall} + 1/h_o$)

C) Product of individual coefficients

D) Difference of individual coefficients

Answer: B

Q40. The Nusselt number (Nu) represents the ratio of:

A) Total heat transfer to conductive heat transfer

B) Convective heat transfer to conductive heat transfer

C) Conductive heat transfer to radiative heat transfer

D) Viscous dissipation to thermal conduction

Answer: B

Q41. Natural convection heat transfer is characterized by which dimensionless group?

A) Peclet number

B) Grashof number (Gr)

C) Stanton number

D) Weber number

Answer: B

Q42. In a counter-current heat exchanger, compared to co-current for the same inlet/outlet temperatures, the LMTD is:

A) Lower

B) Higher

C) Same

D) Zero

Answer: B

Q43. Dropwise condensation gives heat transfer coefficients that are higher than filmwise condensation by approximately:

A) 2 times

B) 5 to 10 times

C) 100 times

D) Equal

Answer: B

Q44. Stefan-Boltzmann law states that total emissive power of a black body is proportional to:

A) T

B) T^2

C) T^3

D) T^4

Answer: D

Q45. Wien's displacement law states that the wavelength of maximum emissive power is inversely proportional to:

A) Absolute temperature (T)

B) Emissivity

C) Surface area

D) Thermal conductivity

Answer: A

Q46. The critical radius of insulation for a cylinder is equal to:

A) k/h

B) $2k/h$

C) h/k

D) $k \cdot h$

Answer: A

Q47. Heat exchanger effectiveness (ϵ) is defined as the ratio of actual heat transfer rate to:

A) Minimum possible heat transfer rate

B) Maximum possible heat transfer rate (Q_{max})

C) Heat loss to surroundings

D) Latent heat of vaporization

Answer: B

Q48. The Dittus-Boelter equation for forced convection in turbulent flow inside tubes applies when Prandtl number range is:

A) $0.7 \le Pr \le 160$

B) $Pr < 0.01$

C) $Pr > 1000$

D) Any Pr value

Answer: A

Q49. Baffles in shell-and-tube heat exchangers are provided primarily to:

A) Support tubes and induce turbulence on the shell side

B) Prevent fouling inside the tubes

C) Decrease shell-side pressure drop

D) Increase tube-side fluid velocity

Answer: A

Q50. Radiation shape factor (view factor) F_{12} between two surfaces depends on:

A) Surface temperatures only

B) Geometry and relative orientation of the surfaces

C) Thermal conductivities

D) Emissivity values

Answer: B

Q51. Kirchhoff's Law of radiation states that at thermal equilibrium, monochromatic emissivity is equal to:

A) Monochromatic absorptivity

B) Monochromatic transmissivity

C) Monochromatic reflectivity

D) Blackbody constant

Answer: A

Q52. Boiling curve peak heat flux is known as:

A) Critical heat flux (CHF) / Burnout point

B) Leidenfrost point

C) Film boiling threshold

D) Subcooled boiling limit

Answer: A

Section 4: Mass Transfer & Separations (Q53–Q70)

Q53. Fick's First Law of diffusion relates mass flux to:

A) Temperature gradient

B) Concentration gradient

C) Velocity gradient

D) Pressure gradient

Answer: B

Q54. The Schmidt number (Sc) is the ratio of:

A) Momentum diffusivity to mass diffusivity (ν/D_{AB})

B) Thermal diffusivity to mass diffusivity

C) Mass transfer coefficient to reaction rate

D) Viscous force to surface tension force

Answer: A

Q55. The Sherwood number (Sh) in mass transfer is analogous to which parameter in heat transfer?

A) Prandtl number

B) Nusselt number

C) Grashof number

D) Stanton number

Answer: B

Q56. The Lewis number (Le) is defined as:

A) Sc/Pr or thermal diffusivity / mass diffusivity (α/D_{AB})

B) Pr/Sc

C) Sh/Nu

D) $Re \cdot Sc$

Answer: A

Q57. In the McCabe-Thiele method for distillation, the q-line slope for a saturated liquid feed is:

A) 0

B) 1

C) Infinite (vertical line)

D) Negative

Answer: C

Q58. Minimum reflux ratio in distillation corresponds to:

A) Minimum number of theoretical stages

B) Infinite theoretical stages

C) Zero reboiler duty

D) Zero condenser heat duty

Answer: B

Q59. Total reflux in distillation results in:

A) Minimum number of theoretical stages

B) Maximum column diameter

C) Zero operating cost

D) Infinite product rate

Answer: A

Q60. Operating reflux ratio in commercial distillation design is typically set around:

A) 1.05 to 1.5 times the minimum reflux ratio

B) 5 to 10 times the minimum reflux ratio

C) Equal to minimum reflux ratio

D) 0.5 times the minimum reflux ratio

Answer: A

Q61. Gas absorption is favored by:

A) High pressure and low temperature

B) Low pressure and high temperature

C) High temperature and high pressure

D) Low pressure and low temperature

Answer: A

Q62. Stripping (desorption) is favored by:

A) Low pressure and high temperature

B) High pressure and low temperature

C) High pressure and high temperature

D) Low pressure and low temperature

Answer: A

Q63. Murphree plate efficiency is calculated based on:

A) Individual tray vapor or liquid concentrations relative to equilibrium

B) Total column length

C) Reflux ratio alone

D) Heat loss per tray

Answer: A

Q64. HETP stands for:

A) Height Equivalent to a Theoretical Plate

B) Heat Energy Transfer Process

C) High Efficiency Tray Performance

D) Height Estimate for Tower Packing

Answer: A

Q65. Choking/Flooding in packed columns occurs when:

A) Gas flow rate is so high that liquid is held up in the packing

B) Liquid flow rate drops to zero

C) Pressure drop is zero

D) Reboiler duty drops

Answer: A

Q66. The unit of overall mass transfer coefficient (K_y) in SI units is typically:

A) $kmol/(m^2 \cdot s \cdot \Delta y)$

B) m/s^2

C) kg/m^3

D) $J/(mol \cdot K)$

Answer: A

Q67. Humidification involves mass transfer of water from:

A) Liquid phase to gas phase

B) Gas phase to liquid phase

C) Solid phase to liquid phase

D) Gas phase to solid phase

Answer: A

Q68. Wet-bulb temperature is lower than dry-bulb temperature when relative humidity is:

A) 100%

B) Less than 100%

C) 0%

D) Greater than 100%

Answer: B

Q69. Extraction selective solvent selection relies primarily on high:

A) Selectivity (distribution coefficient ratio) and low mutual solubility

B) Viscosity

C) Vapor pressure

D) Freezing point

Answer: A

Q70. In drying operations, the constant rate period ends at the:

A) Equilibrium moisture content

B) Critical moisture content

C) Bound moisture content

D) Free moisture limit

Answer: B

Section 5: Chemical Reaction Engineering (Q71–Q85)

Q71. Rate of reaction is defined as the change in moles of a component per unit time per unit:

A) Volume (or mass/surface area of catalyst)

B) Temperature

C) Pressure

D) Enthalpy

Answer: A

Q72. For a elementary reaction $2A + B \rightarrow C$, the order of reaction is:

A) 1

B) 2

C) 3

D) 0

Answer: C

Q73. Arrhenius equation shows that reaction rate constant (k) depends exponentially on:

A) $-E_a/(RT)$

B) $E_a/(RT)$

C) RT/E_a

D) $-\ RT/E_a$

Answer: A

Q74. For an ideal Continuous Stirred Tank Reactor (CSTR) at steady state, composition inside the reactor is:

A) Uniform and equal to exit stream composition

B) Varying along the length

C) Equal to feed composition

D) Changing with time

Answer: A

Q75. For an ideal Plug Flow Reactor (PFR), conversion along the length:

A) Increases monotonically

B) Remains constant

C) Decreases

D) Fluctuates

Answer: A

Q76. For an isothermal, single positive-order reaction, to achieve the same conversion, CSTR volume compared to PFR volume is:

A) Larger

B) Smaller

C) Equal

D) Half

Answer: A

Q77. Space time (τ) in a flow reactor is defined as:

A) Reactor volume divided by volumetric feed flow rate (V/v_0)

B) Volumetric flow rate divided by reactor volume

C) Mass of feed divided by density

D) Residence time of trace elements

Answer: A

Q78. Space velocity is the reciprocal of:

A) Space time

B) Reaction rate

C) Activation energy

D) Conversion

Answer: A

Q79. For autocatalytic reactions, the optimal reactor arrangement to minimize total volume is:

A) CSTR followed by PFR

B) PFR followed by CSTR

C) Single small PFR

D) Equal sized CSTRs in parallel

Answer: A

Q80. In recycle reactors, when the recycle ratio (R) approaches infinity, performance matches that of an ideal:

A) PFR

B) CSTR

C) Batch reactor with zero volume

D) Packed bed reactor

Answer: B

Q81. The E-curve in Residence Time Distribution (RTD) analysis represents:

A) Exit age distribution function

B) Cumulative age distribution function

C) Internal age distribution function

D) Reaction kinetic constant curve

Answer: A

Q82. For an ideal Plug Flow Reactor, the variance (σ^2) of the RTD E-curve is:

A) 0

B) 1

C) Infinity

D) Dependent on reaction order

Answer: A

Q83. Thiele modulus (ϕ) compares:

A) Surface reaction rate to internal pore diffusion rate

B) External mass transfer to heat transfer

C) Convective transport to conductive transport

D) Flow velocity to reaction velocity

Answer: A

Q84. An effectiveness factor (η) close to 1 for a porous catalyst particle indicates:

A) Pore diffusion resistance is negligible (reaction rate controlled)

B) Pore diffusion strictly limits the reaction

C) Heat transfer is controlling

D) Catalyst is poisoned

Answer: A

Q85. Catalyst deactivation due to deposition of carbonaceous materials on active sites is called:

A) Sintering

B) Coking / Fouling

C) Poisoning

D) Leaching

Answer: B

Section 6: Instrumentation, Process Control & Design (Q86–Q100)

Q86. A first-order system with time constant τ responds to a step input. The time taken to reach 63.2% of its ultimate value is:

A) 0.5τ

B) 1.0τ

C) 2.0τ

D) 5.0τ

Answer: B

Q87. Which of the following is a second-order instrument/system?

A) Mercury-in-glass thermometer

B) Bare thermocouple

C) U-tube manometer

D) Liquid storage tank

Answer: C

Q88. Proportional control (P-only) applied to a step response in a first-order system results in:

A) Zero offset

B) Permanent steady-state offset

C) Instability under all gains

D) Derivative action

Answer: B

Q89. Integral control action (I-action) is added primarily to:

A) Eliminate steady-state offset

B) Increase system response speed

C) Anticipate future errors

D) Stabilize second-order noise

Answer: A

Q90. Derivative control action (D-action) acts on the:

A) Rate of change of error

B) Accumulated error over time

C) Absolute value of error

D) Square of error

Answer: A

Q91. Bode stability criterion evaluates stability using:

A) Gain Margin and Phase Margin from frequency response

B) Roots of characteristic equation in right half plane

C) Routh array determinants

D) Time-domain step response overshoot

Answer: A

Q92. Feedforward control measures the:

A) Controlled variable

B) Disturbance directly and acts before output is affected

C) Error signal after process output changes

D) Valve position exclusively

Answer: B

Q93. A control valve with "Equal Percentage" characteristics means:

A) Equal increments in valve lift produce equal percentage changes in flow rate

B) Flow rate varies linearly with valve stem position

C) Valve opens completely at 50% signal

D) Pressure drop across valve is constant

Answer: A

Q94. Air-to-open control valves are designated as:

A) Fail-Closed (FC)

B) Fail-Open (FO)

C) Fail-In-Place

D) Quick opening

Answer: A

Q95. The transfer function of a pure dead-time delay t_d in the Laplace domain is:

A) $e^{-t_d s}$

B) $1/(t_d s + 1)$

C) $t_d s$

D) $1/s^{t_d}$

Answer: A

Q96. Discounted Cash Flow (DCF) method takes into account:

A) Time value of money

B) Straight-line depreciation only

C) Book value of equipment

D) Gross profit margin ignoring interest

Answer: A

Q97. Six-Tenths Rule is used in process design for estimating:

A) Equipment cost based on capacity scaling

B) Pipe diameter based on velocity

C) Heat exchanger surface area

D) Catalyst lifetime

Answer: A

Q98. Operating cost includes:

A) Raw materials, utilities, labor, and maintenance

B) Equipment purchase cost

C) Plant construction cost

D) Land acquisition cost

Answer: A

Q99. Critical Path Method (CPM) in project management identifies:

A) Sequence of tasks with zero total float that determines minimum project duration

B) Most expensive equipment purchases

C) Safety hazard zones in a process plant

D) High risk environmental emissions

Answer: A

Q100. A Rupture Disc is a safety relief device that is:

A) Non-reclosing pressure-relieving device

B) Reclosing spring-loaded valve

C) Temperature controller

D) Flow regulating orifice

Answer: A