FE Chemical

Free practice problems and worked solutions

This sample contains 17 original problems, one from each knowledge area, already available free on EngineerProof. The original Form A problem numbers are retained. This is a sample, not a complete 110-question exam or a predictor of your NCEES result.

Work the questions before consulting the solutions. Each solution includes the calculation and an explanation of the other choices. The full forms, contents, and purchase conditions are at:

https://engineerproof.inshihub.com/fe-chemical

Included knowledge areas

Practice questions

Mathematics

1. A concentration follows $\ln C = 1.20 - 0.035t$, with t in minutes. The time when C=2.0 is most nearly:

   (A) 14.5 min

   (B) 18 min

   (C) 24 min

   (D) 34 min

Probability and Statistics

8. A normally distributed assay has mean 50 and standard deviation 4. Using P(Z>1.5)=0.0668, the probability an assay exceeds 56 is most nearly:

   (A) 0.0668

   (B) 0.134

   (C) 0.433

   (D) 0.933

Engineering Sciences

12. A 20 kg drum is pulled horizontally with 100 N while kinetic friction is 30 N. Its acceleration is most nearly:

    (A) 3.5 m/s^2

    (B) 5 m/s^2

    (C) 6.5 m/s^2

    (D) 70 m/s^2

Materials Science

17. A fully restrained steel member is heated 60 degrees C. With E=200 GPa and thermal expansion coefficient 12e-6 per degree C, compressive thermal stress magnitude is most nearly:

(A) 144 MPa

(B) 240 MPa

(C) 288 MPa

(D) 720 MPa

Chemistry and Biology

21. A monoprotic weak acid has concentration 0.10 M and K_a=1.0e-5. Using x much less than C, solution pH is most nearly:

(A) 1

(B) 2

(C) 2.4

(D) 3

Fluid Mechanics and Dynamics

29. A liquid of density 850 kg/m3 and viscosity 0.012 Pa s flows at 1.8 m/s in a 40 mm pipe. Reynolds number is most nearly:

(A) 204

(B) 2550

(C) 5100

(D) 10200

Thermodynamics

38. An ideal-gas mixture at 500 kPa contains 30 mol% component A. Its partial pressure is most nearly:

    (A) 150 kPa

    (B) 200 kPa

    (C) 350 kPa

    (D) 500 kPa

Material and Energy Balances

47. A steady mixer combines 100 kg/h solution containing 10 wt% solute with 50 kg/h solution containing 30 wt% solute. Product solute mass fraction is most nearly:

    (A) 0.1

    (B) 0.167

    (C) 0.2

    (D) 0.3

Heat Transfer

59. A 0.10 m thick wall with k=0.50 W/(m K), area 8.0 m2, and face temperatures 120 and 30 degrees C conducts heat at a rate most nearly:

    (A) 3600 W

    (B) 4320 W

    (C) 5400 W

    (D) 7200 W

Mass Transfer and Separation

68. A solute diffuses through a stagnant liquid film 1.0 mm thick. Diffusivity is 1.0e-9 m2/s and concentration difference is 2.0 kmol/m3. Steady flux magnitude is most nearly:

(A) 0.000000002 kmol/(m^2 s)

(B) 0.000002 kmol/(m^2 s)

(C) 0.002 kmol/(m^2 s)

(D) 2 kmol/(m^2 s)

Solids Handling

77. A powder has equal mass fractions of 100 micrometer and 400 micrometer particles of equal density and shape. Sauter mean diameter d32=1/sum(w_i/d_i) is most nearly:

(A) 100 micrometer

(B) 160 micrometer

(C) 250 micrometer

(D) 400 micrometer

Chemical Reaction Engineering

80. When reactant concentration doubles, measured initial rate increases by a factor of four at constant temperature. Reaction order in that reactant is most nearly:

(A) 0.5

(B) 1

(C) 2

(D) 4

Economics

88. A process upgrade costs USD 120,000 now and returns USD 35,000 at each year-end for 5 years. At 8%, net present worth is most nearly:

(A) -120000 USD

(B) 1980 USD

(C) 15796 USD

(D) 19745 USD

Process Design

92. A 10 m3 vessel costs USD 200,000. Using six-tenths scaling, estimated cost of a geometrically similar 40 m3 vessel is most nearly:

(A) 459479 USD

(B) 551375 USD

(C) 800000 USD

(D) 1600000 USD

Process Control

99. A first-order process with gain 2.0 and time constant 5 min receives a unit step. Output after 5 min is most nearly:

(A) 0.632

(B) 1

(C) 1.01

(D) 1.26

Safety, Health, and Environment

103. A vapor leak enters ventilation air at 2.0 kg/h while clean air flow is 1,000 kg/h. Assuming dilute mixing, vapor mass fraction is most nearly:

(A) 0.0002

(B) 0.002

(C) 0.02

(D) 0.5

Ethics and Professional Practice

108. A process engineer discovers that a relief-valve calculation used the wrong reaction heat and the installed valve may be undersized. Startup is scheduled. The engineer should:

(A) Document the error, notify responsible management, and withhold approval until the hazard is resolved

(B) Approve startup because the valve has not yet failed

(C) Delete the calculation and repeat it after startup

(D) Let the equipment vendor decide without disclosing the error

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Worked solutions

Mathematics

Problem 1

Answer: (A)

A concentration follows $\ln C = 1.20 - 0.035t$, with t in minutes. The time when C=2.0 is most nearly:

Solving $\ln 2 = 1.20 - 0.035t$ *gives t=14.5 min.*

The target concentration fixes the left side of the linear logarithmic model.

$$0.6931 = 1.20 - 0.035t$$

Isolating time gives the crossing point.

$$t = (1.20 - 0.6931)/0.035 = 14.5 \text{ min}$$

FE REFERENCE HANDBOOK — MATHEMATICS: LOGARITHMS

WHY THE OTHER CHOICES APPEAR

- **(B)** Using base-10 logarithm in place of the stated natural logarithm overstates time.
- **(C)** Dropping the intercept before solving gives an unsupported value.
- **(D)** Dividing the intercept alone by the decay coefficient ignores the target concentration.

Probability and Statistics

Problem 8

Answer: (A)

A normally distributed assay has mean 50 and standard deviation 4. Using P(Z>1.5)=0.0668, the probability an assay exceeds 56 is most nearly:

The standardized value is (56-50)/4=1.5, so the requested upper-tail probability is 0.0668.

Standardization measures distance from the mean in standard deviations.

$$z = (56 - 50)/4 = 1.5$$

The supplied upper-tail area applies directly.

$$P(X > 56) = P(Z > 1.5) = 0.0668$$

FE REFERENCE HANDBOOK — PROBABILITY: NORMAL DISTRIBUTION

WHY THE OTHER CHOICES APPEAR

- **(B)** Doubling the one-tail probability gives the two-tail probability outside plus-or-minus 1.5.
- **(C)** Subtracting the upper-tail area from one-half gives the area between mean and z=1.5.
- **(D)** Using the lower cumulative probability answers X less than 56.

Engineering Sciences

Problem 12

Answer: (A)

A 20 kg drum is pulled horizontally with 100 N while kinetic friction is 30 N. Its acceleration is most nearly:

Net force is 70 N, so acceleration is 70/20=3.5 m/s2.

Collinear forces combine before applying Newton's second law.

$$F_{net} = 100 - 30 = 70 \text{ N}$$

Mass converts net force to acceleration.

$$a = F_{net}/m = 70/20 = 3.5 \text{ m/s}^2$$

FE REFERENCE HANDBOOK — ENGINEERING SCIENCES: FORCE, MASS, AND ACCELERATION

WHY THE OTHER CHOICES APPEAR

- **(B)** Ignoring friction gives 100/20=5 m/s2.
- **(C)** Adding friction to applied force overstates net force.
- **(D)** Reporting net force as acceleration omits mass.

Materials Science

Problem 17

Answer: (A)

A fully restrained steel member is heated 60 degrees C. With E=200 GPa and thermal expansion coefficient 12e-6 per degree C, compressive thermal stress magnitude is most nearly:

Full restraint converts free thermal strain alpha delta T into stress E alpha delta T=144 MPa compression.

The member's prevented free strain is alpha times temperature change.

$$\epsilon_T = 12 \times 10^{-6}(60) = 7.2 \times 10^{-4}$$

Elastic stress balances that restrained strain.

$$\mid \sigma \mid = E\epsilon_T = 200000(7.2 \times 10^{-4}) = 144 \text{ MPa}$$

FE REFERENCE HANDBOOK — MATERIALS SCIENCE: THERMAL STRESS

WHY THE OTHER CHOICES APPEAR

- **(B)** Using only one-sixth of the temperature rise understates stress.
- **(C)** Multiplying modulus and expansion coefficient but omitting part of temperature rise gives an unrelated result.
- **(D)** Using half the elastic modulus gives half the restrained stress.

Chemistry and Biology

Problem 21

Answer: (D)

A monoprotic weak acid has concentration 0.10 M and K_a=1.0e-5. Using x much less than C, solution pH is most nearly:

Weak-acid equilibrium gives [H+]=sqrt(K_a C)=0.001 M, so pH=3.00.

Neglecting x relative to initial concentration reduces the dissociation equation.

$$K_a \approx x^2/C$$

Hydrogen-ion concentration determines pH.

$$x = \sqrt{10^{-5}(0.10)} = 10^{-3} \text{ M}$$

$$pH = 3.00$$

FE REFERENCE HANDBOOK — CHEMISTRY: WEAK-ACID EQUILIBRIA

WHY THE OTHER CHOICES APPEAR

- **(A)** Treating the weak acid as fully dissociated gives pH 1.
- **(B)** Using hydrogen concentration equal to K_a gives pH 5, while pH 2 reflects an unrelated square-root error.
- **(C)** Applying an unsupported 20% final scaling understates the result obtained from the governing relation.

Fluid Mechanics and Dynamics

Problem 29

Answer: (C)

A liquid of density 850 kg/m3 and viscosity 0.012 Pa s flows at 1.8 m/s in a 40 mm pipe. Reynolds number is most nearly:

Re=rho V D/mu=5,100.

Pipe Reynolds number compares inertial and viscous effects.

$$Re = \frac{\rho V D}{\mu}$$

The diameter is 0.040 m.

$$Re = 850(1.8)(0.040)/0.012 = 5100$$

FE REFERENCE HANDBOOK — FLUID MECHANICS: REYNOLDS NUMBER

WHY THE OTHER CHOICES APPEAR

(A) Using pipe radius and an extra viscosity factor understates Reynolds number.

(B) Using radius instead of diameter halves Reynolds number.

(D) Using twice the pipe diameter doubles Reynolds number.

Thermodynamics

Problem 38

Answer: (A)

An ideal-gas mixture at 500 kPa contains 30 mol% component A. Its partial pressure is most nearly:

Dalton's law gives p_A=y_A P=0.30(500)=150 kPa.

Ideal-mixture partial pressure is proportional to mole fraction.

$$p_A = y_A P$$

The component occupies 30% of the total moles.

$$p_A = 0.30(500) = 150 \text{ kPa}$$

FE REFERENCE HANDBOOK — THERMODYNAMICS: IDEAL-GAS MIXTURES

WHY THE OTHER CHOICES APPEAR

- **(B)** Using the complement mole fraction and an unrelated half factor gives 200 kPa.
- **(C)** Using component B's 70% fraction gives its partial pressure.
- **(D)** Reporting total pressure ignores mixture composition.

Material and Energy Balances

Problem 47

Answer: (B)

A steady mixer combines 100 kg/h solution containing 10 wt% solute with 50 kg/h solution containing 30 wt% solute. Product solute mass fraction is most nearly:

Solute flow is 10+15=25 kg/h in 150 kg/h product, so mass fraction is 0.1667.

Total and solute balances both apply to the nonreactive mixer.

$$\dot{m}_P = 100 + 50 = 150 \text{ kg/h}$$

$$\dot{m}_s = 100(0.10) + 50(0.30) = 25 \text{ kg/h}$$

Product composition is component flow divided by total flow.

$$w_s = 25/150 = 0.1667$$

FE REFERENCE HANDBOOK — MATERIAL BALANCES: STEADY MIXING

WHY THE OTHER CHOICES APPEAR

- **(A)** Using only the dilute feed composition ignores the concentrated stream.
- **(C)** Taking an unweighted average ignores unequal feed flow rates.
- **(D)** Using only the concentrated feed composition ignores dilution.

Heat Transfer

Problem 59

Answer: (A)

A 0.10 m thick wall with k=0.50 W/(m K), area 8.0 m2, and face temperatures 120 and 30 degrees C conducts heat at a rate most nearly:

Fourier conduction gives Q=kA delta T/L=3,600 W.

One-dimensional steady wall conduction is proportional to area and temperature difference.

$$\dot{Q} = kA(T_1 - T_2)/L$$

The temperature difference is 90 K.

$$\dot{Q} = 0.50(8.0)(90)/0.10 = 3600 \text{ W}$$

FE REFERENCE HANDBOOK — HEAT TRANSFER: PLANE-WALL CONDUCTION

WHY THE OTHER CHOICES APPEAR

- **(B)** Applying an unsupported 20% final scaling overstates the result obtained from the governing relation.
- **(C)** Applying an unsupported 50% final scaling overstates the result obtained from the governing relation.
- **(D)** Using half the wall thickness doubles heat rate.

Mass Transfer and Separation

Problem 68

Answer: (B)

A solute diffuses through a stagnant liquid film 1.0 mm thick. Diffusivity is 1.0e-9 m2/s and concentration difference is 2.0 kmol/m3. Steady flux magnitude is most nearly:

Fick's law gives N=D delta C/L=2.0e-6 kmol/(m2 s).

A linear steady concentration profile gives constant diffusive flux.

$$|\, N_A| = D_{AB} \frac{|\, C_{A1} - C_{A2}|}{L}$$

The film thickness is 0.0010 m.

$$|\, N_A| = 10^{-9}(2.0)/0.0010 = 2.0 \times 10^{-6} \text{ kmol}/(\text{m}^2 \text{ s})$$

FE REFERENCE HANDBOOK — MASS TRANSFER: FICK'S FIRST LAW

WHY THE OTHER CHOICES APPEAR

- **(A)** Multiplying diffusivity by concentration difference without dividing by film thickness understates flux.
- **(C)** Using film thickness in millimetres as though it were metres overstates conversion.
- **(D)** Omitting diffusivity gives a concentration-gradient quantity, not molar flux.

Solids Handling

Problem 77

Answer: (B)

A powder has equal mass fractions of 100 micrometer and 400 micrometer particles of equal density and shape. Sauter mean diameter d32=1/sum(w_i/d_i) is most nearly:

d32=1/(0.5/100+0.5/400)=160 micrometres.

The surface-volume mean weights inverse diameter by mass fraction for equal density.

$$1/d_{32} = \sum w_i/d_i$$

The inverse mean is 0.00625 per micrometre.

$$d_{32} = 1/(0.005 + 0.00125) = 160\ \mu\ \mathrm{m}$$

FE REFERENCE HANDBOOK — SOLIDS HANDLING: PARTICLE SIZE DISTRIBUTIONS

WHY THE OTHER CHOICES APPEAR

(A) Using only the fine fraction ignores coarse particles.

(C) Taking an arithmetic mean does not give surface-volume mean diameter.

(D) Using only the coarse fraction ignores the added surface from fines.

Chemical Reaction Engineering

Problem 80

Answer: (C)

When reactant concentration doubles, measured initial rate increases by a factor of four at constant temperature. Reaction order in that reactant is most nearly:

For r proportional to C^n, 4=2^n, so n=2.

Rate ratios eliminate the constant rate coefficient.

$$r_2/r_1 = (C_2/C_1)^n$$

The observed ratios are four and two.

$$4 = 2^n$$

$$n = 2$$

FE REFERENCE HANDBOOK — REACTION ENGINEERING: RATE LAWS AND ORDER

WHY THE OTHER CHOICES APPEAR

(A) Taking the square root of the rate ratio gives concentration ratio, not order.

(B) First order would double rate when concentration doubles.

(D) Using the rate factor directly as order ignores exponentiation.

Economics

Problem 88

Answer: (D)

A process upgrade costs USD 120,000 now and returns USD 35,000 at each year-end for 5 years. At 8%, net present worth is most nearly:

Present worth of returns is USD 139,745; minus initial cost gives NPW about USD 19,745.

Uniform annual returns use the present-worth annuity factor.

$$NPW = 35000(P/A, 8\%, 5) - 120000$$

The factor is 3.9927.

$$NPW = 35000(3.9927) - 120000 = 19745 \text{ USD}$$

FE REFERENCE HANDBOOK — ECONOMICS: NET PRESENT WORTH

WHY THE OTHER CHOICES APPEAR

(A) Reporting initial cost alone omits annual returns.

(B) Using an overly rounded annuity factor nearly eliminates the positive worth.

(C) Applying an unsupported 20% final scaling understates the result obtained from the governing relation.

Process Design

Problem 92

Answer: (A)

A 10 m3 vessel costs USD 200,000. Using six-tenths scaling, estimated cost of a geometrically similar 40 m3 vessel is most nearly:

C2=C1(S2/S1)^0.6=200,000(4^0.6)=USD 459,479.

Capacity-cost scaling uses the specified empirical exponent.

$$C_2 = C_1(S_2/S_1)^{0.6}$$

The capacity ratio is four.

$$C_2 = 200000(4^{0.6}) = 459479 \text{ USD}$$

FE REFERENCE HANDBOOK — PROCESS DESIGN: EQUIPMENT COST SCALING

WHY THE OTHER CHOICES APPEAR

(B) Applying an unsupported 20% final scaling overstates the result obtained from the governing relation.

(C) Using linear scaling assumes cost grows directly with capacity.

(D) Using capacity ratio squared greatly overstates scale economy.

Process Control

Problem 99

Answer: (D)

A first-order process with gain 2.0 and time constant 5 min receives a unit step. Output after 5 min is most nearly:

After one time constant, response is K(1-e^-1)=1.264.

A first-order step response approaches final gain exponentially.

$$y(t) = K\Delta u(1 - e^{-t/\tau})$$

At t=tau and unit step, the normalized fraction is 0.632.

$$y = 2.0(0.6321) = 1.264$$

FE REFERENCE HANDBOOK — PROCESS CONTROL: FIRST-ORDER DYNAMICS

WHY THE OTHER CHOICES APPEAR

(A) Using unit process gain gives the normalized response only.

(B) Assuming output reaches half or full unit after one time constant ignores gain and exponential response.

(C) Applying an unsupported 20% final scaling understates the result obtained from the governing relation.

Safety, Health, and Environment

Problem 103

Answer: (B)

A vapor leak enters ventilation air at 2.0 kg/h while clean air flow is 1,000 kg/h. Assuming dilute mixing, vapor mass fraction is most nearly:

Mixed mass fraction is 2/(1,002)=0.001996, about 0.20 wt%.

A dilute steady enclosure balance places leak mass in total exhaust flow.

$$w_v = \dot{m}_v/(\dot{m}_{air} + \dot{m}_v)$$

Total mixed flow is 1,002 kg/h.

$$w_v = 2/1002 = 0.001996$$

FE REFERENCE HANDBOOK — SAFETY: VENTILATION AND DISPERSION

WHY THE OTHER CHOICES APPEAR

(A) Using 10,000 kg/h instead of 1,000 kg/h understates concentration.

(C) Using 100 kg/h ventilation overstates concentration tenfold.

(D) Assuming equal leak and air flows ignores the stated dilution.

Ethics and Professional Practice

Problem 108

Answer: (A)

A process engineer discovers that a relief-valve calculation used the wrong reaction heat and the installed valve may be undersized. Startup is scheduled. The engineer should:

A credible overpressure protection deficiency must be disclosed and resolved before professional startup approval.

Reaction heat directly affects runaway relief load, making the discovered input error material to safety.

A corrected independent relief calculation can verify capacity before startup and create an auditable decision basis.

FE REFERENCE HANDBOOK — ETHICS: PUBLIC SAFETY AND OBJECTIVE REPORTING

WHY THE OTHER CHOICES APPEAR

(B) Absence of a prior failure does not establish adequate relief capacity for a known scenario.

(C) Deleting the calculation conceals evidence and allows an unresolved public-safety risk.

(D) Vendor input may help, but the engineer must disclose the basis error and ensure responsible resolution.