SOLUTION

CADET _____ SECTION _____TIME OF DEPARTURE _____

DEPARTMENT OF CHEMISTRY & LIFE SCIENCE

CH402, AY2023-2024
WRITTEN PARTIAL REVIEW II
55 Minutes, 6 March 2024

TEXT: Peters, Timmerhaus, & West
SCOPE: Chapters 4, 6-8

References Permitted: FE Reference Handbook, Calculator.

INSTRUCTIONS

1. You will have 55 minutes for the examination.
2. There are 11 problems on 3 pages in this exam, not including the cover page.
3. Do not mark this exam or open it until "begin work" is given.
4. Write your name on the top of each page.
5. There is one correct response for each question. Circle each correct response.
6. Use pencils only. Use the margins and the back of the exam for scratch work.

(TOTAL WEIGHT: 200 POINTS)

DO NOT WRITE IN THIS SPACE

PROBLEM	VALUE	CUT
1	18	A
2	18	C
3	18	D
4	20	B
5	18	B
6	18	D
7	18	A
8	18	C
9	18	A
10	18	C
11	18	B
TOTAL CUT		/200
TOTAL SCORE		/200

Cadet: SOLUTION

Problems 1 and 2 pertain to a $10,000 bond with an interest rate of 9% paying quarterly. The bond was issued three years ago and matures 10 years after the date of issue. The market interest rate is 12% per year compounded quarterly.

1. (18 points) The amount of interest the bond holder receives every three months is

(A) $225
(B) $450
(C) $600
(D) $300

Solution: 9% annual interest paying quarterly is 2.25% of the face value, or $225 //ANS

2. (18 points) The present value of the bond is most nearly

(A) $8,279
(B) $8,606
(C) $8,593
(D) $9,245

Solution: The present value of the bond is the present value of the payments plus the present value of the redemption value, both at the market interest rate because these accrue interest at that rate. There are seven years left on the bond so there are 28 payments remaining (7·4=28). Since n=28 is not in the tables, the factors must be calculated from the formulas on page 230 of the FEE Reference Manual.

$$\begin{aligned} P &= 225\cdot(P/A,3\%,28)+10000\cdot(P/F,3\%,28) \\ &= 225\cdot\frac{(1+.03)^{28}-1}{.03\cdot(1+.03)^{28}}+10000\cdot(1+.03)^{-28} \\ &= 225\cdot 18.7641+10000\cdot .4371 \\ &= \$8,593 \text{ //ANS} \end{aligned}$$

Cadet: SOLUTION

3. (18 points) If $15,000 is placed into a savings account and $27,250 is anticipated in five years, what annual interest rate is needed if interest is compounded monthly?

(A) 1 %
(B) 18 %
(C) 15 %
(D) 12 %

Solution: At 6 years compounded monthly, there are 60 interest periods. Go "to F given P," use the formula on page 230 of the FEE Reference Manual, and solve for i.

$$F = P \cdot (F/P, i\%, 60)$$
$$27250 = 15000 \cdot (1+i)^{60}$$
$$i = .01 \text{ per period, or } 12\% \text{ per year} \quad //ANS$$

4. (20 points) The purchase cost of a heat exchanger is $35,000, annual maintenance costs are $3,500, and the salvage value is $14,000. The exchanger has a service life of 5 years, at which time the project is to be *terminated* and the salvage value recovered. What is the *present value* of the heat exchanger assuming an interest rate is 10%?

(A) $43,693
(B) $39,575
(C) $56,960
(D) $48,268

Solution Notes:
- Purchased cost and annual cost are positive cash outlays (outflows). Since salvage is capital recovery, it is a negative cash outlay. *Positive* salvage value will result in answer C.
- Cadets will also get answer D ignoring salvage value.

Solution: Convert annual costs and salvage value to present values and add those to the purchased cost. Use (P/A) to convert the annual costs. The salvage value occurs in the future when the salvage is made, so use (P/F) to convert to present. The required factors for i=10% and n=5 years can be found on page 236 of the FEE Reference Manual.

$$P = \text{purchase cost} + \text{annual cost} \cdot (P/A, 10\%, 5) - \text{salvage value} \cdot (P/F, 10\%, 5)$$
$$= \text{purchase cost} + \text{annual cost} \cdot 3.7908 - \text{salvage value} \cdot 0.6209$$

$$P = 35000 + 3500 \cdot 3.7908 - 14000 \cdot 0.6209 = \$39,575 \quad //ANS$$

Cadet: SOLUTION

5. (18 points) A company can manufacture a product in a machine shop outfitted with manually operated machine tools. The required machine tools will cost $1,100,000 and the manufacturing cost per unit will be $2,500. As an alternative course of action, a completely automated machine shop will cost $1,700,000 with manufacturing cost per unit of $1,900. The annual production volume required to reach a breakeven point of 1.33 years is most nearly:

(A) 972
(B) 751
(C) 501
(D) 650

Solution: The definition of breakeven analysis appears on page 231 of the FEE Reference Manual:

> "By altering the value of any one of the variables in a situation, holding all of the other values constant, it is possible to find a value for that variable that makes the two alternatives equally economical. This value is the break-even point."

Breakeven in this case is the number of production years (n) after which the cumulative cash position of these two courses of action are equal.

$$1{,}100{,}000 + \frac{\$2{,}500}{\text{unit}} \cdot \frac{\text{n units}}{\text{y}} \cdot 1.33\,\text{y} = 1{,}700{,}000 + \frac{\$1{,}900}{\text{unit}} \cdot \frac{\text{n units}}{\text{y}} \cdot 1.33\,\text{y} \rightarrow \text{n} = 751 \tfrac{\text{units}}{\text{y}}$$ //ANS

6. (18 points) A recently purchased 6-foot carbon-steel bubble-cap tray cost $4,900. A similar tray has a purchase cost of $3,200. Its diameter is most nearly:

(A) 3.7 ft
(B) 2.3 ft
(C) 8.6 ft
(D) 4.2 ft

Solution: Scaling of equipment costs is on pages 258 of the FEE Reference Manual.

$$\text{Cost of A} = \text{Cost of B}\left(\frac{\text{Capacity of A}}{\text{Capacity of B}}\right)^{n} \rightarrow \$3{,}200 = \$4{,}900\left(\frac{\text{x}}{6\text{ft}}\right)^{1.20}$$

$$\text{x} = 4.21\text{ ft}$$ //ANS

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7. (18 points) The diagram that a user produces in CHEMCAD most resembles

(A) a process flow diagram
(B) a functions diagram
(C) a piping and instrumentation diagram
(D) an input/output diagram

Solution: Different types of flow diagrams are discussed on pages 77-79 of the PTW text.

8. (18 points) The input/output analysis is most commonly used to assess

(A) Costs associated with process energy requirements.
(B) Equipment costs associated with a process or plant
(C) The overall economic potential of a process or plant
(D) Market values of reactants and products.

Solution: The I/O analysis is discussed on page 126 and in examples 4-1 and 4-2 of the PTW text. Energy costs are sometimes included, as in problem 4-13, but answer is C.

9. (18 points) Which of the following items is not seen in a functions diagram:

(A) Finishing and pre-processing boxes
(B) Reactor and separator boxes
(C) Heating and cooling loads
(D) Recycle, product, and feed streams

Solution: See discussion on page 126 and example 4-3 in the PTW text.

10. (18 points) Which of the following is most likely to appear in the white section of the NFPA fire/hazard diamond for H_2SO_4?

(A) ~~W~~
(B) Cor
(C) ACID
(D) OX

Solution: Look up. Defined on page 14 of the FEE Reference Manual.

11. (18 points) Which of the following is most likely to ignite and burn in air?

(A) 2.4% acetylene
(B) 2.3% ethyl acetate
(C) 7.2% gasoline
(D) 4.9% natural gas

Solution: Defined on page 19 of the FE Reference Manual. Assume natural gas is mostly methane.