

AMERICAN SOCIETY OF PENSION PROFESSIONALS & ACTUARIES  
JOINT BOARD FOR THE ENROLLMENT OF ACTUARIES  
SOCIETY OF ACTUARIES

**Enrolled Actuaries Basic Examination**

**EA-1**

Date: Thursday, May 9, 2024

**INSTRUCTIONS TO CANDIDATES**

1. Special conditions generally applicable to all questions on this examination are found on the next page.
2. On this examination the symbol “ $a$ ” will be used to represent an annuity. On this examination the symbol “ $\ell_x$ ” will be used to represent the number of lives at age  $x$ .
3. This examination consists of 34 multiple-choice questions worth a total of 100 points. The point value for each question is shown in parentheses at the beginning of the question.
4. Your score will be based on the point values of questions that you answer correctly. No credit will be given for omitted answers and no credit will be lost for wrong answers; hence, you should answer all questions even those for which you have to guess.
5. Do not spend too much time on any one question. If a question seems too difficult, leave it and go on.
6. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the computer screen.
7. Use the scratch paper booklets provided by Prometric for your scratch work. Extra scratch paper booklets are available if you run out of scratch paper in the booklet provided to you.

**Answer Key EA-1 Spring 2024**  
**February 28, 2024**

<b>Question</b>	<b>Answer</b>
1	C
2	C
3	C
4	A
5	D
6	D
7	B
8	B
9	E
10	A
11	A
12	C
13	B
14	B
15	B
16	C
17	B
18	D
19	E
20	E
21	C
22	E
23	B
24	B
25	D
26	D
27	B
28	C
29	C
30	C
31	B
32	D
33	B
34	B

## CONDITIONS GENERALLY APPLICABLE TO ALL EA-1 EXAMINATION QUESTIONS

**If applicable, the following conditions should be considered a part of the data for each question, unless otherwise stated or implied.**

- (1) The normal retirement age is 65.
- (2) Retirement pensions commence at normal retirement age and are paid monthly for life at the beginning of each month.
- (3) There are no pre-retirement death or disability benefits.
- (4) Actuarial equivalence is based on the mortality table and interest rate assumed for funding purposes.
- (5) Interest rates that are compounded more frequently than annually are expressed as nominal rates.
- (6) Where multiple lives are involved, future lifetimes are assumed to be independent of each other.
- (7) The term “gross single premium” is equivalent to “contract single premium;” the term “net single premium” is equivalent to “single benefit premium;” the term “gross annual premium” is equivalent to “annual contract premium;” the term “net annual premium” is equivalent to “annual benefit premium.”
- (8) There are no policy loans in effect.
- (9) For a bond, the face amount and the redemption value are the same.
- (10) Interest rate equals yield rate.
- (11) The term “duration” means “Macaulay duration”.

**If applicable, the preceding conditions should be considered a part of the data for each question, unless otherwise stated or implied.**

Data for Question 1 (2 points)

\$5,000 will accumulate to \$7,000 at a rate of simple interest  $i$  over a period  $t$ .

$X$  = the accumulated value of \$750 at a rate of simple interest  $0.75i$  over period  $2t$ .

Question 1

In what range is  $X$ ?

- (A) Less than \$1,110
- (B) \$1,110 but less than \$1,160
- (C) \$1,160 but less than \$1,210
- (D) \$1,210 but less than \$1,260
- (E) \$1,260 or more

Data for Question 2 (3 points)

A 5-year certificate of deposit yields the following:

6.0% per year, compounded monthly for years 1 and 2

6.8% per year, compounded quarterly for year 3

7.6% per year, compounded semiannually for years 4 and 5

$X$  = the effective annual interest rate earned over the 5-year period.

Question 2

In what range is  $X$ ?

- (A) Less than 6.80%
- (B) 6.80% but less than 6.90%
- (C) 6.90% but less than 7.00%
- (D) 7.00% but less than 7.10%
- (E) 7.10% or more

Data for Question 3 (2 points)

Smith invests \$1,000 that accrues interest monthly.

$$d^{(2)}=0.06$$

$X$  = the accumulated value of Smith's investment after one year.

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Question 3

In what range is  $X$ ?

- (A) Less than \$1,060
- (B) \$1,060 but less than \$1,062
- (C) \$1,062 but less than \$1,064
- (D) \$1,064 but less than \$1,066
- (E) \$1,066 or more

Data for Question 4 (4 points)

$$\ddot{a}_{\overline{n+1}|} = 8.36009$$

$$v^n = 0.55839$$

Question 4

In what range is  $(Ia)_{\overline{2n}|}$ ?

- (A) Less than 100
- (B) 100 but less than 130
- (C) 130 but less than 160
- (D) 160 but less than 190
- (E) 190 or more

Data for Question 5 (3 points)

Smith purchases a 20-year immediate annuity-certain and pays for it with a single premium.

The terms of the annuity follow:

In each of the first 10 years, \$50,000 is paid in equal monthly installments.

In each of the next 10 years, \$25,000 is paid in equal quarterly installments.

Interest rate: 4.00% per year, compounded semiannually.

$X$  = the single premium paid by Smith.

Question 5

In what range is  $X$ ?

- (A) Less than \$525,000
- (B) \$525,000 but less than \$535,000
- (C) \$535,000 but less than \$545,000
- (D) \$545,000 but less than \$555,000
- (E) \$555,000 or more



Data for Question 6 (3 points)

Smith borrows \$100,000 and will repay it with level payments at the end of each month.

The lender offers Smith two options for the repayment:

	<u>Option 1</u>	<u>Option 2</u>
Interest rate:	Nominal 6.00% per year, compounded monthly	Nominal 4.00% per year, compounded monthly
Term:	30 years	15 years

$X$  = the absolute value of the difference in the amount of interest Smith will pay over the life of the loan between Option 1 and Option 2

Question 6

In what range is  $X$ ?

- (A) Less than \$60,500
- (B) \$60,500 but less than \$70,500
- (C) \$70,500 but less than \$80,500
- (D) \$80,500 but less than \$90,500
- (E) \$90,500 or more

Data for Question 7 (3 points)

Terms of a loan:

Amount of loan:  $X$   
Repayment period: 20 years  
Payments: Level annual payments at the end of each year

Interest portion of the 11<sup>th</sup> payment: \$172.01

Interest portion of the 16<sup>th</sup> payment: \$92.35

Question 7

In what range is  $X$ ?

- (A) Less than \$9,950
- (B) \$9,950 but less than \$10,150
- (C) \$10,150 but less than \$10,350
- (D) \$10,350 but less than \$10,550
- (E) \$10,550 or more

Data for Question 8 (3 points)

Terms of a bond:

Face amount:	\$1,000
Term:	5 years
Coupon rate:	4.00%, payable semiannually

The bond is purchased to yield 6.00% per year, compounded annually.

$X$  = the total amount for accumulation of discount during the third year of the bond.

Question 8

In what range is  $X$ ?

- (A) Less than \$16.13
- (B) \$16.13 but less than \$16.33
- (C) \$16.33 but less than \$16.53
- (D) \$16.53 but less than \$16.73
- (E) \$16.73 or more

Data for Question 9 (3 points)

Selected data for two bonds that have the same annual yield to maturity:

	<u>Bond A</u>	<u>Bond B</u>
Par value	\$1,000	\$1,000
Coupon rate	5.00%, payable annually	10.42%, payable annually
Term to maturity	10 years	15 years
Price	A discount of \$166.66	A premium of $X$

Question 9

In what range is  $X$ ?

- (A) Less than \$155
- (B) \$155 but less than \$190
- (C) \$190 but less than \$225
- (D) \$225 but less than \$260
- (E) \$260 or more

Data for Question 10 (2 points)

The term structure of interest rates is given below:

<u>Length of investment</u> <u>(years)</u>	<u>Spot rate</u>
1	3.00%
2	4.00%
3	<i>X</i>

The 2-year deferred, 1-year spot rate implied by the current spot rates is 5.51%.

Question 10

In what range is *X*?

- (A) Less than 5.00%
- (B) 5.00% but less than 6.25%
- (C) 6.25% but less than 7.50%
- (D) 7.50% but less than 8.75%
- (E) 8.75% or more

Data for Question 11 (2 points)

Term structure of interest rates:

<u>Term (years)</u>	<u>Spot rate</u>
1	5.00%
2	5.75%
3	6.25%
4	6.65%

A \$1,000 three-year bond is redeemable at par and pays annual 4.0% coupons.

$X$  = the price of the bond.

Question 11

In what range is  $X$ ?

- (A) Less than \$950
- (B) \$950 but less than \$975
- (C) \$975 but less than \$1,000
- (D) \$1,000 but less than \$1,025
- (E) \$1,025 or more

Data for Question 12 (3 points)

A portfolio of assets consists of two investments:

1. A \$1,000 par value bond with a coupon of \$75 payable each 12/31 and a term of 3 years. This bond is redeemable at par.
2. A \$1,000 zero coupon bond with a term of 10 years.

The interest rate is 6.0% per year, compounded annually.

$X$  = the modified duration of this portfolio.

Question 12

In what range is  $X$ ?

- (A) Less than 4.85 years
- (B) 4.85 years but fewer than 4.94 years
- (C) 4.94 years but fewer than 5.03 years
- (D) 5.03 years but fewer than 5.12 years
- (E) 5.12 years or more

Data for Question 13 (3 points)

Pension fund asset information for 2024:

Market value as of 1/1/2024 .....	\$30,000,000
Monthly benefit payments .....	\$100,000, paid on the first day of each calendar month
Contribution to the fund.....	\$750,000, deposited on 9/15/2024
Market value as of 12/31/2024 .....	\$31,500,000

$X$  = the dollar-weighted rate of return for the calendar year.

Question 13

In what range is  $X$ ?

- (A) Less than 6.57%
- (B) 6.57% but less than 6.61%
- (C) 6.61% but less than 6.65%
- (D) 6.65% but less than 6.69%
- (E) 6.69% or more



Data for Question 14 (3 points)

Terms of a bond:

Face amount:     \$1,000  
Term:             15 years  
Coupon rate:     4.00%, payable annually

For a bond in good standing at the beginning of a year, the probability of default is 0.8% during that year.

$X$  = the price an investor would pay to yield 5.00% per year, compounded annually.

Question 14

In what range is  $X$ ?

- (A)    Less than \$810
- (B)    \$810 but less than \$850
- (C)    \$850 but less than \$890
- (D)    \$890 but less than \$930
- (E)    \$930 or more

Data for Question 15 (3 points)

A company creates a fund for Smith with the following specifications:

Contributions of 6% of an employee's beginning-of-year salary are deposited in a fund at the end of each year.

Smith's annual salary at the beginning of the first year of the fund is \$50,000.

Each subsequent year, Smith's salary is 3.0% more than the prior year's salary.

Smith's account balance earns 7.0% per year, compounded annually.

No distributions are made out of the fund.

$X$  = Smith's account balance at the end of 20 years.

Question 15

In what range is  $X$ ?

- (A) Less than \$145,000
- (B) \$145,000 but less than \$155,000
- (C) \$155,000 but less than \$165,000
- (D) \$165,000 but less than \$175,000
- (E) \$175,000 or more

Data for Question 16 (3 points)

For a pension fund, employees are subject to three independent causes of decrement: disability ( $i$ ), turnover ( $w$ ), and retirement ( $r$ ).

A section of the applicable multiple decrement table is shown below:

<u>Age (<math>x</math>)</u>	<u><math>l_x^{(T)}</math></u>	<u><math>d_x^{(i)}</math></u>	<u><math>d_x^{(w)}</math></u>	<u><math>d_x^{(r)}</math></u>
60	1,000	50	50	100
61	800	48	32	160
62	560	39	17	168
63	336	27	7	168
64	134	12	1	67
65	54	0	0	54

$X$  = the probability that an employee age 60 will either become disabled before age 62 or retire on or after age 63.

Question 16

In what range is  $X$ ?

- (A) Less than 0.20
- (B) 0.20 but less than 0.30
- (C) 0.30 but less than 0.40
- (D) 0.40 but less than 0.50
- (E) 0.50 or more

Data for Question 17 (3 points)

Terms of an annuity-immediate, payable to a life age  $x$  at 1/1/2023:

Payment: \$100,000 per year, payable annually on December 31  
beginning on 12/31/2023

Interest: 5.0% per year, compounded annually

Base mortality rates in 2023:

$$q_x = 0.051$$

$$q_{x+1} = 0.057$$

$$q_{x+2} = 0.063$$

Mortality rates are projected to improve by 1.0% per year, compounded annually.

$X$  = the present value, at age  $x$ , of the payment made on 12/31/2025.

Question 17

In what range is  $X$ ?

- (A) Less than \$72,500
- (B) \$72,500 but less than \$72,600
- (C) \$72,600 but less than \$72,700
- (D) \$72,700 but less than \$72,800
- (E) \$72,800 or more

Data for Question 18 (3 points)

For a 1-year select and ultimate mortality table, you are given the following:

$$\ddot{a}_{65} = 10.7563$$

$$p_{[65]} = 1.015p_{65}$$

$$X = \ddot{a}_{[65]}$$

Question 18

In what range is  $X$ ?

- (A) Less than 10.875
- (B) 10.875 but less than 10.885
- (C) 10.885 but less than 10.895
- (D) 10.895 but less than 10.905
- (E) 10.905 or more

Data for Question 19 (2 points)

Smith, age 40, purchases a \$50,000 whole life insurance policy with death benefit payable at the end of the year of death.

Selected commutation functions:

$\underline{x}$	$\underline{N_x}$
40	5,000
41	4,500

Interest rate: 8.0% per year, compounded annually.

$X$  = the net single premium for this policy.

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Question 19

In what range is  $X$ ?

- (A) Less than \$11,000
- (B) \$11,000 but less than \$11,500
- (C) \$11,500 but less than \$12,000
- (D) \$12,000 but less than \$12,500
- (E) \$12,500 or more

Data for Question 20 (3 points)

You are given the following mortality assumption for integral ages:

$$q_x = \begin{cases} 0, & x < 20 \\ 0.10 & x = 20 \\ 0.05 & x > 20 \end{cases}$$

Interest rate: 4.0% per year, compounded annually

$$X = \ddot{a}_{20}$$

Question 20

In what range is  $X$ ?

- (A) Less than 9.30
- (B) 9.30 but less than 9.80
- (C) 9.80 but less than 10.30
- (D) 10.30 but less than 10.80
- (E) 10.80 or more

Data for Question 21 (4 points)

Smith (age 60) purchases the following financial product:

Annual annuity payment    \$10,000 per year

Payment frequency and timing    Annually at the end of each year

Death benefit                    10 payments of \$5,000 per year, with the first payment at the end of the year of Smith's death

Assumptions to use in this calculation:

Interest: 5.0% per year, compounded annually

Selected commutation functions:

$$D_{60} = 4,846$$

$$N_{60} = 61,572$$

$X$  = the present value of this financial product.

Question 21

In what range is  $X$ ?

- (A)    Less than \$132,500
- (B)    \$132,500 but less than \$133,000
- (C)    \$133,000 but less than \$133,500
- (D)    \$133,500 but less than \$134,000
- (E)    \$134,000 or more



Data for Question 22 (2 points)

Smith (age 20) buys a five-year temporary life annuity-due, with the following scheduled payments:

<u>Payment number</u>	<u>Amount</u>
1	\$1.00
2	\$3.00
3	\$5.00
4	\$7.00
5	\$9.00

You are given the following values:

$$(Ia)_{\overline{20:\overline{4}|}} = 7$$

$$a_{\overline{20:\overline{4}|}} = 3$$

$X$  = the single premium for this annuity.

Question 22

In what range is  $X$ ?

- (A) Less than \$11.00
- (B) \$11.00 but less than \$13.00
- (C) \$13.00 but less than \$15.00
- (D) \$15.00 but less than \$17.00
- (E) \$17.00 or more

Data for Question 23 (4 points)

Values from a mortality table:

$x$	$q_x$
$0 \leq x \leq 35$	$\frac{1}{101}$
$36 \leq x \leq 75$	$\frac{2}{102}$
$x = 76$	1

$X = e_0$

Question 23

In what range is  $X$ ?

- (A) Less than 48.85
- (B) 48.85 but less than 49.35
- (C) 49.35 but less than 49.85
- (D) 49.85 but less than 50.35
- (E) 50.35 or more

Data for Question 24 (3 points)

A college maintains a stationary population of 15,000 students.

Students are admitted only at age 18 and 19.

Selected values from a life table:

$x$	$l_x$	$L_x$	$T_x$
18	100,000	97,917	266,668
19	93,750	85,417	168,751
20	75,000	60,417	83,334
21	56,250	22,917	22,917
22	0	0	0

Annual admissions at age 18: 4,000

$X$  = annual admissions at age 19.

Question 24

In what range is  $X$ ?

- (A) Less than 2,250
- (B) 2,250 but less than 2,500
- (C) 2,500 but less than 2,750
- (D) 2,750 but less than 3,000
- (E) 3,000 or more

Data for Question 25 (3 points)

A continuous \$1 annuity is payable to Smith (age 30) for life, beginning at the death of Jones (age 40).

In addition, the annuity is payable if either Smith or Jones is alive after age 65 for the life of the survivor(s).

Selected annuity values:

$$\bar{a}_{30} = 12.00$$

$$\bar{a}_{40} = 10.00$$

$$\bar{a}_{30:40} = 6.00$$

$$\bar{a}_{40:\overline{25}|} = 7.00$$

$X$  = the net single premium for this annuity.

Question 25

In what range is  $X$ ?

- (A) Less than \$6.50
- (B) \$6.50 but less than \$7.50
- (C) \$7.50 but less than \$8.50
- (D) \$8.50 but less than \$9.50
- (E) \$9.50 or more

Data for Question 26 (3 points)

The probability that two lives age 20 and 40 both survive 20 years is  $\frac{2}{3}$ .

Out of 750 lives all age 20, 50 are expected to die before reaching age 30.

$X$  = the probability that a 30-year-old will not survive to age 60.

Question 26

In what range is  $X$ ?

- (A) Less than 0.15
- (B) 0.15 but less than 0.20
- (C) 0.20 but less than 0.25
- (D) 0.25 but less than 0.30
- (E) 0.30 or more

Data for Question 27 (3 points)

You are reviewing information about four people, all of whom are age 40.

Mortality has the following assumptions:

$$\ell_x = 100 - x, 0 \leq x \leq 100$$

$X$  = the probability that at least two of the four people will not survive for at least 20 years.

Question 27

In what range is  $X$ ?

- (A) Less than 0.37
- (B) 0.37 but less than 0.42
- (C) 0.42 but less than 0.47
- (D) 0.47 but less than 0.52
- (E) 0.52 or more

Data for Question 28 (3 points)

In a double-decrement table, you are given the following values:

$$q_x^{(1)} = 0.06$$

$$q_x^{(1)} = \frac{q_x^{(2)}}{3}$$

Each decrement is uniformly distributed in its associated single decrement tables.

$$X = q_x^{(2)}$$

Question 28

In what range is  $X$ ?

- (A) Less than 0.1625
- (B) 0.1625 but less than 0.1675
- (C) 0.1675 but less than 0.1725
- (D) 0.1725 but less than 0.1775
- (E) 0.1775 or more

Data for Question 29 (3 points)

For a double-decrement table where decrement ( $d$ ) is death and decrement ( $w$ ) is withdrawal, you are given the following:

Deaths are uniformly distributed over each integral year of age in the associated single-decrement table.

Withdrawals occur at the beginning of each year.

$$\ell_{20}^{(T)} = 1,000$$

$$q_{20}^{(w)} = 0.250$$

$$d_{20}^{(d)} = 0.040d_{20}^{(w)}$$

$$X = q_{20}^{(d)}$$

Question 29

In what range is  $X$ ?

- (A) Less than 0.0092
- (B) 0.0092 but less than 0.0113
- (C) 0.0113 but less than 0.0134
- (D) 0.0134 but less than 0.0155
- (E) 0.0155 or more



Data for Question 30 (3 points)

Smith is offered the following actuarially equivalent payment options:

- Option 1 .....\$60,000 per year, payable for life
- Option 2 .....\$45,000 per year, payable for life, with \$45,000 per year continuing to Smith's spouse after Smith's death
- Option 3 ..... $X$  per year, payable for life, with  $0.5X$  per year continuing to Smith's spouse after Smith's death

Question 30

In what range is  $X$ ?

- (A) Less than \$47,500
- (B) \$47,500 but less than \$50,000
- (C) \$50,000 but less than \$52,500
- (D) \$52,500 but less than \$55,000
- (E) \$55,000 or more

Data for Question 31 (3 points)

Smith (age 62) is entitled to a normal retirement benefit of \$1,200 per month, payable beginning at Smith's age 65.

The retirement plan provides that Smith may elect an actuarially-equivalent early retirement benefit payable beginning at Smith's age 62.

The retirement plan's assumptions for actuarial equivalence purposes are:

Interest rate:	7.00% per year, compounded annually		
Pre-retirement mortality:	None.		
Post-retirement mortality:	Selected commutation functions:		
	$\underline{x}$	$\frac{N_x^{(12)}}{x}$	$\frac{D_x}{x}$
	62	153,674	14,273
	63	139,866	13,254
	64	127,054	12,295
	65	115,172	11,394

$X$  = the actuarially-equivalent early retirement monthly benefit payable to Smith beginning at age 62.

Question 31

In what range is  $X$ ?

- (A) Less than \$900
- (B) \$900 but less than \$950
- (C) \$950 but less than \$1,000
- (D) \$1,000 but less than \$1,050
- (E) \$1,050 or more

Data for Question 32 (4 points)

Smith (age 60) is entitled to receive a life annuity with annual payments of \$10,000 payable at the end of each year while Smith is alive.

Instead of receiving this annuity, Smith elects an actuarially equivalent 5-year certain and life annuity-immediate with annual payments of  $X$ .

Mortality is based on the formula:  $l_x = 100 - x$ ,  $x \geq 0$ .

$i = 4.0\%$ , compounded annually.

Question 32

In what range is  $X$ ?

- (A) Less than \$8,600
- (B) \$8,600 but less than \$9,000
- (C) \$9,000 but less than \$9,400
- (D) \$9,400 but less than \$9,800
- (E) \$9,800 or more

Data for Question 33 (3 points)

Smith (age 60) purchases a whole life insurance policy with a face value of \$100,000, with the benefit payable at the end of the year of death.

Selected actuarial values:

$$a_{61} = 11.5060$$

$$q_{60} = 0.004803$$

Interest rate: 6.0% per year, compounded annually

$X$  = the net single premium for this policy

Question 33

In what range is  $X$ ?

- (A) Less than \$25,500
- (B) \$25,500 but less than \$28,500
- (C) \$28,500 but less than \$31,500
- (D) \$31,500 but less than \$34,500
- (E) \$34,500 or more

Data for Question 34 (3 points)

Deaths are uniformly distributed between consecutive integral ages.

$$q_x=0.20$$

$$q_{x+1}=0.40$$

$$X = q_{x+0.40}$$

Question 34

In what range is  $X$ ?

- (A) Less than 0.265
- (B) 0.265 but less than 0.275
- (C) 0.275 but less than 0.285
- (D) 0.285 but less than 0.295
- (E) 0.295 or more

**\*\*END OF EXAMINATION\*\***