1. A bacteria culture doubles in size in 8 hours. How long will it take for the size to triple? Assume that the rate of increase of the culture is proportional to the size.

   Select the correct answer.

   (a) 12.7 hours
   (b) 13.1 hours
   (c) 13.5 hours
   (d) 13.9 hours
   (e) 14.3hours

2. The half-life of plutonium 239 is 24,200 years. Assume that the decay rate is proportional to the amount. An initial amount of 3 grams of radium would decay to 2 grams in approximately

   Select the correct answer.

   (a) 12200 years
   (b) 14200 years
   (c) 15200 years
   (d) 17200 years
   (e) 18200 years

3. An object is taken out of a 21°C room and placed outside where the temperature is 4°C room. Twenty-five minutes later the temperature is 17°C. It cools according to Newton's Law. The temperature of the object after one hour is

   Select the correct answer.

   (a) 12.2°C
   (b) 12.9°C
   (c) 13.6°C
   (d) 14.3°C
   (e) 15.0°C

4. A chicken is taken out of the freezer (0°C) and placed on a table in a 23°C room. Forty-five minutes later the temperature is 10°C. It warms according to Newton's Law. How long does it take before the temperature reaches 20°C?

   Select the correct answer.

   (a) 147 minutes
   (b) 153 minutes
   (c) 157 minutes
   (d) 161 minutes
   (e) 165 minutes

5. In Newton's Law of cooling, $\dfrac{dT}{dt} = k(T - T_m)$, T_m is

   Select the correct answer.

   (a) the temperature of the object
   (b) the temperature of the environment
   (c) the initial temperature
   (d) the temperature after a specified period of time
   (e) none of the above

6. A tank contains 200 liters of water in which 300 grams of salt is dissolved. A brine solution containing 0.4 kilograms of salt per liter of water is pumped into the tank at the rate of 5 liters per minute, and the well-stirred mixture is pumped out at the same rate. Let $A(t)$ represent the amount of salt in the tank at time t. The correct initial value problem for $A(t)$ is

   Select the correct answer.

   (a) $\dfrac{dA}{dt} = 2 + A/40,\ A(0) = 0.3$
   (b) $\dfrac{dA}{dt} = 2 - A/40,\ A(0) = 0.3$
   (c) $\dfrac{dA}{dt} = 5 + A/40,\ A(0) = 300$
   (d) $\dfrac{dA}{dt} = 5 - A/40,\ A(0) = 300$
   (e) $\dfrac{dA}{dt} = 0.4 - A/40,\ A(0) = 300$

7. In the previous problem, how much salt will there be in the tank after a long period of time?

   Select the correct answer.

   (a) 1000 kilograms
   (b) 300 kilograms
   (c) 120 kilograms
   (d) 80 kilograms
   (e) none of the above

8. The amount of salt in the tank at time t in the previous two problems is

   Select the correct answer.

   (a) $A(t) = -200 + 200.3e^{t/40}$
   (b) $A(t) = 200 - 199.7e^{-t/40}$
   (c) $A(t) = 80 - 79.7e^{-t/40}$
   (d) $A(t) = -80 + 80.3e^{t/25}$
   (e) $A(t) = 200 + 100e^{-t/40}$

9. The differential equation $\dfrac{dP}{dt} = (k\cos t)P$, where k is a positive constant, models a population that undergoes yearly fluctuations. The solution of the equation is

   Select the correct answer.

   (a) $P = e^{ck\sin t}$
   (b) $P = ce^{k\cos t}$
   (c) $P = ce^{-k\cos t}$
   (d) $P = ce^{-k\sin t}$
   (e) $P = ce^{k\sin t}$

10. In the logistic model for population growth, $\dfrac{dP}{dt} = P(12 - 3P)$, what is the carrying capacity of the population $P(t)$?

    Select the correct answer.

    (a) 4
    (b) 1/4
    (c) 12
    (d) 3

11. The solution of the equation $\dfrac{dP}{dt} = P(12 - 3P)$ with initial condition $P(0) = 3$ is

    Select the correct answer.

    (a) $P = 12/(3 + e^{-12t})$
    (b) $P = 4/(3 + e^{-12t})$
    (c) $P = 4/(3 - e^{-12t})$
    (d) $P = 3/(12 + e^{-12t})$
    (e) $P = 3/(4 + e^{-12t})$

12. Two chemicals, A and B, are combined, forming chemical C. The rate of the reaction is jointly proportional to the amounts of A and B not yet converted to C. Initially, there are 50 grams of A and 80 grams of B, and, during the reaction, for each two grams of A used up in the conversion, there are three grams of B used up. An experiments shows that 100 grams of C are produced in the first ten minutes. After a long period of time, how much of A and of B remains, and how much of C has been produced?

    Select the correct answer.

    (a) 30 grams of A, 0 grams of B, 100 grams of C
    (b) 0 grams of A, 30 grams of B, 100 grams of C
    (c) 10 grams of A, 0 grams of B, 120 grams of C
    (d) 0 grams of A, 5 grams of B, 125 grams of C
    (e) 0 grams of A, 0 grams of B, 130 grams of C

13. In the previous problem, the amount of chemical C, $X(t)$, produced by time t is

    Select the correct answer.

    (a) $X = 2000(1 - e^{-25kt/3})/(16 - 15e^{-25kt/3})$, where $k = 3\ln(5/4)/250$
    (b) $X = 2000(1 - e^{-125kt})/(4 - e^{-125kt})$, where $k = \ln(19/16)/1250$
    (c) $X = 400(1 - e^{-25kt/3})/(3 - e^{-25kt/3})$, where $k = 3\ln(3)/250$
    (d) $X = 400(1 - e^{-125kt})/(3 - e^{-125kt})$, where $k = \ln(3)/1250$
    (e) $X = 800(1 - e^{-25kt/3})/(4 - e^{-25kt/3})$, where $k = 3\ln(7/4)/250$

14. Radioactive element X decays to element Y with decay constant -0.5. Y, in turn, decays to stable element Z with decay constant -0.1. What is the system of differential equations for the amounts, $x(t)$, $y(t)$, $z(t)$ of the elements X, Y, Z, respectively, at time t, if the initial conditions are $x(0) = 10$, $y(0) = 0$, $z(0) = 0$.

    Select the correct answer.

    (a) $\frac{dx}{dt} = -0.5x$, $\frac{dy}{dt} = 0.1x - 0.5y$, $\frac{dz}{dt} = 0.2y$
    (b) $\frac{dx}{dt} = -0.5x$, $\frac{dy}{dt} = 0.5x - 0.1y$, $\frac{dz}{dt} = 0.5y$
    (c) $\frac{dx}{dt} = -0.5x$, $\frac{dy}{dt} = 0.5x - 0.1y$, $\frac{dz}{dt} = 0.1y$
    (d) $\frac{dx}{dt} = -0.1x$, $\frac{dy}{dt} = 0.1x - 0.5y$, $\frac{dz}{dt} = 0.1y$
    (e) $\frac{dx}{dt} = -0.1y$, $\frac{dy}{dt} = 0.5x - 0.1z$, $\frac{dz}{dt} = 0.5y$

15. In the previous problem, how much of X, Y, and Z are left after a long period of time?

    Select the correct answer.

    (a) $x = 0$, $y = 5$, $z = 5$
    (b) $x = 5$, $y = 5$, $z = 0$
    (c) $x = 5$, $y = 0$, $z = 5$
    (d) $x = 0$, $y = 0$, $z = 10$
    (e) none of the above

16. The solution of the system of differential equations in the two previous problems is

    Select the correct answer.

    (a) $x = 10e^{-0.1t}$, $y = 12.5(e^{-0.1t} - e^{-0.5t})$, $z = 10 - 12.5e^{-0.1t} + 2.5e^{-0.5t}$
    (b) $x = 10e^{-0.1t}$, $y = 12.5(e^{-0.5t} - e^{-0.1t})$, $z = 10 - 12.5e^{-0.5t} + 2.5e^{-0.1t}$
    (c) $x = 10e^{-0.5t}$, $y = 12.5(e^{-0.5t} - e^{-0.1t})$, $z = 10 - 12.5e^{-0.2t} + 2.5e^{-0.3t}$
    (d) $x = 10e^{-0.5t}$, $y = 12.5(e^{-0.1t} - e^{-0.5t})$, $z = 10 - 12.5e^{-0.5t} + 2.5e^{-0.1t}$
    (e) $x = 10e^{-0.5t}$, $y = 12.5(e^{-0.1t} - e^{-0.5t})$, $z = 10 - 12.5e^{-0.1t} + 2.5e^{-0.5t}$

17. Tank A contains 50 gallons of water in which 2 pounds of salt has been dissolved. Tank B contains 30 gallons of water in which 3 pounds of salt has been dissolved. A brine mixture with a concentration of 0.8 pounds of salt per gallon of water is pumped into tank A at the rate of 3 gallons per minute. The well-mixed solution is then pumped from tank A to tank B at the rate of 4 gallons per minute. The solution from tank B is also pumped through another pipe into tank A at the rate of 1 gallon per minute, and the solution from tank B is also pumped out of the system at the rate of 3 gallons per minute. The correct differential equations with initial conditions for the amounts, $x(t)$ and $y(t)$, of salt in tanks A and B, respectively, at time t are

    Select the correct answer.

    (a) $\dfrac{dx}{dt} = 3 - 2x/25 + y/5,\ \dfrac{dy}{dt} = x/25 - y/15,\ x(0) = 2,\ y(0) = 3$

    (b) $\dfrac{dx}{dt} = 3 - x/25 + y/15,\ \dfrac{dy}{dt} = 2x/25 - 2y/15,\ x(0) = 2,\ y(0) = 3$

    (c) $\dfrac{dx}{dt} = 2.4 - 2x/25 + y/30,\ \dfrac{dy}{dt} = 2x/25 - 2y/15,\ x(0) = 2,\ y(0) = 3$

    (d) $\dfrac{dx}{dt} = 2.4 - x/50 + y/30,\ \dfrac{dy}{dt} = x/40 - y/3,\ x(0) = 2,\ y(0) = 3$

    (e) $\dfrac{dx}{dt} = 2.4 - x/25 + y/15,\ \dfrac{dy}{dt} = x/50 - y/30,\ x(0) = 2,\ y(0) = 3$

18. In the previous problem, how much salt will there be in tanks A and B after a long period of time?

    Select the correct answer.

    (a) 3 pounds in A, 2 pounds in B

    (b) 40 pounds in A, 24 pounds in B

    (c) 0 pounds in A, 0 pounds in B

    (d) 40 pounds in A, 30 pounds in B

    (e) none of the above

19. In the Lotka-Volterra predator-prey model $\dfrac{dx}{dt} = -ax + bxy,\ \dfrac{dy}{dt} = ey - cxy$, where $x(t)$ is the predator population and $y(t)$ is the prey population, the coefficient e represents which of the following:

    Select the correct answer.

    (a) the predator die-off rate

    (b) the prey growth rate

    (c) the increase in the predator population due to interactions with the prey

    (d) the decrease in the prey population due to interactions with the predator

    (e) none of the above

20. In the competition model $\dfrac{dx}{dt} = ax - bxy$, $\dfrac{dy}{dt} = cy - dxy$, where $x(t)$ and $y(t)$ are the populations of the competing species, moose and deer, respectively, the coefficient d represents which of the following:

    Select the correct answer.

    (a) the moose growth rate
    (b) the deer growth rate
    (c) the decrease in the moose population due to interactions with the deer
    (d) the decrease in the deer population due to interactions with the moose
    (e) none of the above

ANSWER KEY
Zill Differential Equations 9e Chapter 3 Form D

1. a
2. b
3. b
4. d
5. b
6. b
7. d
8. c
9. e
10. a
11. a
12. d
13. a
14. c
15. d
16. e
17. c
18. b
19. b
20. d