SQA Past paper questions

2023 – Paper 2 – Question 13

A patient is given a dose of medicine.

The concentration of the medicine in the patient's blood is modelled by

$$C_t = 11e^{-0.0053t}$$

where:

- t is the time, in minutes, since the dose of medicine was given
- C_t is the concentration of the medicine, in mg/l, at time t.

(a) Calculate the concentration of the medicine 30 minutes after the dose was given. 1

The dose of medicine becomes ineffective when its concentration falls to 0.66 mg/l.

(b) Calculate the time taken for this dose of the medicine to become ineffective. 3

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2022 – Paper 2 – Question 10

The heptathlon is an athletics contest made up of seven events.

Athletes score points for each event.

In the 200 metres event, the points are calculated using the formula

$$P = 4.99087(42.5 - T)^{1.81}$$

where P is the number of points awarded, and T is the athlete's time, in seconds.

(a) Calculate how many points would be awarded for a time of 24.55 seconds in the 200 metres event. 1

In the long jump event, the points are calculated using the formula

$$P = 0.188807(D - 210)^{k}$$

where P is the number of points awarded, D is the distance jumped, in centimetres, and k is a constant.

(b) Given that 850 points are awarded for a jump of 600 cm, calculate the value of k. 4

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2019 – Paper 2 – Question 9

Electricity on a spacecraft can be produced by a type of nuclear generator.
The electrical power produced by this generator can be modelled by

$$P_t = 120e^{-0.0079t}$$

where P_t is the electrical power produced, in watts, after t years.

(a) Determine the electrical power initially produced by the generator. 1

(b) Calculate how long it takes for the electrical power produced by the generator to reduce by 15%. 4

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2018 – Paper 2 – Question 11

A supermarket has been investigating how long customers have to wait at the checkout.
During any half hour period, the percentage, $P\%$, of customers who wait for less than t minutes, can be modelled by

$$P = 100\left(1 - e^{kt}\right), \text{ where } k \text{ is a constant.}$$

(a) If 50% of customers wait for less than 3 minutes, determine the value of k. 4

(b) Calculate the percentage of customers who wait for 5 minutes or longer. 2

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2016 – Paper 2 – Question 6

Scientists are studying the growth of a strain of bacteria. The number of bacteria present is given by the formula

$$B(t) = 200e^{0.107t},$$

where t represents the number of hours since the study began.

(a) State the number of bacteria present at the start of the study. 1

(b) Calculate the time taken for the number of bacteria to double. 4

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Specimen – Paper 2 – Question 7

Given that $P(t) = 30e^{t-2}$ decide whether each of the statements below is true or false. Justify your answers.

Statement A $P(0) = 30$.

Statement B When $P(t) = 15$, the only possible value of t is 1·3 to one decimal place.

6

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2013 – Paper 2 – Question 9

The concentration of the pesticide, *Xpesto*, in soil can be modelled by the equation

$$P_t = P_0 e^{-kt}$$

where:

- P_0 is the initial concentration;
- P_t is the concentration at time t;
- t is the time, in days, after the application of the pesticide.

(*a*) Once in the soil, the half-life of a pesticide is the time taken for its concentration to be reduced to one half of its initial value.

If the half-life of *Xpesto* is 25 days, find the value of k to 2 significant figures. 4

(*b*) Eighty days after the initial application, what is the percentage decrease in concentration of *Xpesto*? 3

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2009 – Paper 2 – Question 6

The size of the human population, N, can be modelled using the equation $N = N_0 e^{rt}$ where N_0 is the population in 2006, t is the time in years since 2006, and r is the annual rate of increase in the population.

(*a*) In 2006 the population of the United Kingdom was approximately 61 million, with an annual rate of increase of 1·6%. Assuming this growth rate remains constant, what would be the population in 2020? 2

(*b*) In 2006 the population of Scotland was approximately 5·1 million, with an annual rate of increase of 0·43%.

Assuming this growth rate remains constant, how long would it take for Scotland's population to double in size? 3

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2006 – Paper 2 – Question 11

It is claimed that a wheel is made from wood which is over 1000 years old.

To test this claim, carbon dating is used.

The formula $A(t) = A_0 e^{-0.000124t}$ is used to determine the age of the wood, where A_0 is the amount of carbon in any living tree, $A(t)$ is the amount of carbon in the wood being dated and t is the age of the wood in years.

For the wheel it was found that $A(t)$ was 88% of the amount of carbon in a living tree.

Is the claim true? **5**

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2005 – Paper 2 – Question 9

The value V (in £ million) of a cruise ship t years after launch is given by the formula $V = 252e^{-0.06335t}$.

(*a*) What was its value when launched? **1**

(*b*) The owners decide to sell the ship once its value falls below £20 million. After how many years will it be sold? **4**

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2004 – Paper 2 – Question 10

The amount A_t micrograms of a certain radioactive substance remaining after t years decreases according to the formula $A_t = A_0 e^{-0.002t}$, where A_0 is the amount present initially.

(*a*) If 600 micrograms are left after 1000 years, how many micrograms were present initially? **3**

(*b*) The half-life of a substance is the time taken for the amount to decrease to half of its initial amount. What is the half-life of this substance? **4**

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2001 – Paper 2 – Question 9

Before a forest fire was brought under control, the spread of the fire was described by a law of the form $A = A_0 e^{kt}$ where A_0 is the area covered by the fire when it was first detected and A is the area covered by the fire t hours later.

If it takes one and half hours for the area of the forest fire to double, find the value of the constant k. **3**

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1992 – Paper 2 – Question 4

(*a*) For a particular radioactive substance, the mass m (in grams) at time t (in years) is given by

$$m = m_0 e^{-0.02t}$$

where m_0 is the original mass.

If the original mass is 500 grams, find the mass after 10 years. **2**

(*b*) The half-life of any material is the time taken for half of the mass to decay.

Find the half-life of this substance. **3**

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1989 – Paper 1 – Question 20

Medical researchers studying the growth of a strain of bacteria observe that the number of bacteria, present after t hours, is given by the formula

$$N(t) = 40e^{1.5t}.$$

(*a*) State the number of bacteria present at the start of the experiment. **1**

(*b*) How many minutes will the bacteria take to double in number? **4**

(5)

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