OCR
Oxford Cambridge and RSA

Friday 19 January 2024 – Afternoon

Level 3 Cambridge Technical in Applied Science

05874 Unit 23: Scientific research techniques

Time allowed: 2 hours
C344/2401

C344 – 2401

You must have:
- your copy of the Pre-release

You can use:
- a scientific or graphical calculator
- an HB pencil

0 5 8 7 4 – 2 3

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- At the end of the exam, hand in your pre-release notes with your exam paper.
- Use the Pre-release to answer Questions **4** and **5**.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

1 Jane is an assistant in an engineering laboratory. She investigates new materials for use in extreme environments.

Jane sets up a testing rig to test 30 components made from material **Q**.

She measures and records the time taken, in hours, for each component to fail.

(a) Six of the components take 91 hours to fail.

Use this information to complete the data recording sheet below.

Add headings, with appropriate units, to the top of the data recording sheet.

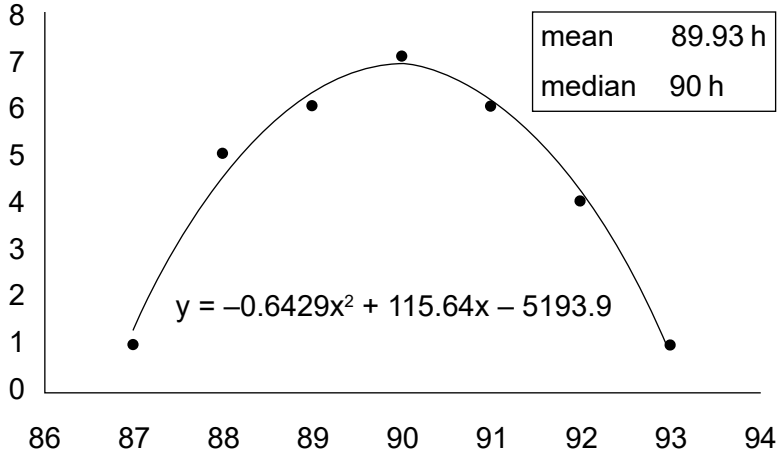
.....	.....
87	1
88	5
89	6
90	7
.....	.....
92	4
93	1
Total	.....

[2]

(b) Jane uses a computer to produce a scatter graph of her results. The computer does not display the axis labels.

The computer software calculates the trendline and displays the formula of the trendline.

It also displays some statistical information as shown below.



(i) Which **other** type of graph could Jane use to display this type of continuous data?

..... **[1]**

(ii) Jane's data is normally distributed.

Which **other** statistical calculation can she make to show the variation in her data?

..... **[1]**

(iii) Jane repeats her test using materials **R** and **S**.

Suggest why Jane should use statistical language in her conclusions about the results of her tests.

.....

..... **[1]**

2 Kobe is a trainee laboratory assistant. He attends a course on biosafety in the workplace and learns four essential practices:

A. Conducting a biological risk assessment

B. Using appropriate safety equipment

C. Designing facilities to prevent the release of harmful biological agents

D. Following good laboratory techniques and practices

Write one letter **A**, **B**, **C** or **D** against each sentence in the table to identify which essential practice applies to each one.

You may use each letter once, more than once, or not at all.

Sentence	**Letter**
Laboratory personnel should also understand their roles and be instructed to perform their duties in emergencies, from power outages to incidental spills or deliberate malicious acts.	
Biological Safety Level (BSL)-1 and BSL-2 laboratories, for instance, must have isolation from public access, availability of decontamination equipment (e.g., autoclave), and handwashing facilities.	
Appraising and setting procedures to make sure that laboratory workers and the public are safe.	
They are considered the first line of defense against biohazards and include enclosed containers, safety centrifuge cups, and biosafety cabinets.	

[4]

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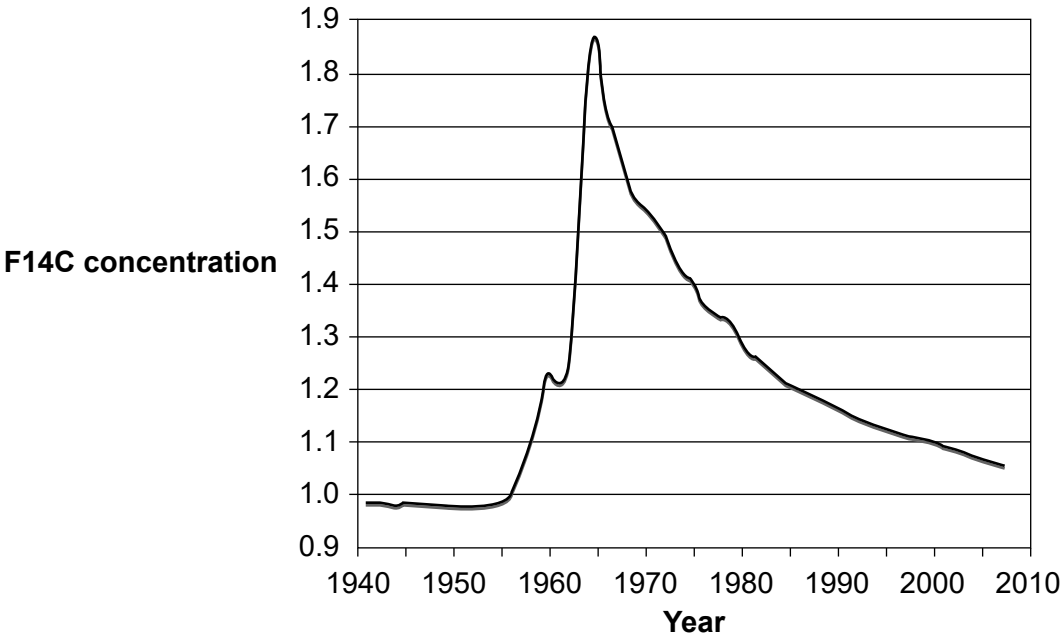
PLEASE DO NOT WRITE ON THIS PAGE

Turn over for the next question

3 Carbon-14 is a radioactive isotope of carbon, known as radiocarbon. It has a radioactive half-life of 5730 years and is used as a tool by archaeologists to find the age of organic materials.

Atmospheric nuclear testing during the 1950s and early 1960s caused the concentration of carbon-14 (F14C) in the atmosphere to change as shown in the graph below.

This post-testing change in the level of atmospheric radiocarbon is of interest to forensic scientists.



(a) The values of F14C in the graph are the averages of atmospheric measurements taken during the normal plant growing season in the world's northern hemisphere, from 1940 to 2007.

(i) Which natural process causes atmospheric carbon to decrease during the plant growing season?

..... **[1]**

(ii) Suggest **two** explanations for the shape of the graph after 1966.

1 .....

.....

2 .....

.....

[2]

(b) A piece of organic material is tested for the presence and level of F14C by a forensic scientist.

Use the graph to explain why there is a level of uncertainty in their conclusions. Give data to support your answer.

Explanation .....

.....

.....

.....

Data .....

.....

[2]

(c) The following abstract appeared in a journal of forensic science.

> **Abstract**
>
> The capacity for high monetary returns encourages counterfeiting of art objects. The art market's confidential protocols make the problem worse. Radiocarbon analysis provides a tool to detect anachronistic* materials. Measurement of post-testing radiocarbon, which was observed in the atmosphere during the last 70 years, can provide clear evidence of post-1950 material. Here we briefly introduce the method and discuss its application in detecting forgeries. Three accelerator mass spectrometry (AMS) laboratories performed a radiocarbon dating comparison study on materials used in art. Results obtained from tests carried out on modern cotton paper, antique sheets of paper, parchment, and a textile, demonstrate the radiocarbon dating capacity to date the material accurately.
>
> adapted from: Hajdas *et al*
>
> https://doi.org/10.1016/j.forsciint.2022.111292

* Belonging to a period different to the one claimed.

(i) What is the scope of the research?

.....

..... **[1]**

(ii) Which of the following statements is the hypothesis for this abstract?

Tick (✓) **one** box.

Changes to atmospheric radiocarbon levels have been detected during the last 70 years.	☐
Mass spectrometry is used to detect the presence of post-testing radiocarbon.	☐
The detection of post-testing radiocarbon levels shows that artwork is a forgery if it claims to have been produced before 1950.	☐
The technique of radiocarbon dating has been shown to be accurate using a range of paper and textile materials.	☐

[1]

(iii) Three different accelerator mass spectrometry (AMS) laboratories performed a comparison study on the same art materials.

How will the results of this study increase confidence in the method?

.....

..... **[1]**

(iv) The abstract describes the protocols that are used by the art market to analyse artworks as 'confidential'.

Explain why scientists are more likely to support the conclusions of other scientists whose protocols are **not** confidential.

.....

.....

.....

.....

.....

..... **[3]**

Questions **4** and **5** relate to the pre-release material you have studied and your secondary research.

4

(a) With reference to **Source A**.

Describe **four** advantages of using biologically-derived polymer packaging.

1 .....

.....

2 .....

.....

3 .....

.....

4 .....

.....

[4]

(b) **Source A** refers to clean labelling.

Consumers associate clean-labelled products with claims such as “only natural ingredients”.

Use the evidence in **Source A** to suggest **one** claim that could be made about the food wrapped in the packaging described. Support your answer with a quotation from the source.

Claim .....

.....

Quotation .....

.....

[2]

(c) The value pK_a, which is introduced in **Source A**, is related to pH.

The table shows a few of the techniques used to determine the value of pK_a and the year when they were first used.

Technique	**Year of first use**
spectrometry	1925
electrophoresis	1946
calorimetry	1997
computational	1998

When selecting appropriate techniques, factors such as reliability, repeatability and cost must be considered.

State **three** other factors that must be considered. For each factor suggest a reason to explain why new techniques for the measurement of pK_a have been developed over the decades.

Factor 1 .....

Explanation .....

.....

.....

Factor 2 .....

Explanation .....

.....

.....

Factor 3 .....

Explanation .....

.....

.....

[6]

(d) Compare **Sources A** and **B** in relation to their perspective, their academic rigour and their use of secondary data. Give examples from the sources to support your answers.

Perspective:

Source A .....

.....

.....

Source B .....

.....

.....

Academic rigour:

Source A .....

.....

.....

Source B .....

.....

.....

Secondary data:

Source A .....

.....

.....

Source B .....

.....

.....

[8]

5 Write a report on your own research related to the pre-release material, including the following:

- the area of focus you have chosen
- the findings from your research
- evaluation of your research with reference to:
  - method(s) chosen
  - evidence generated
  - source material(s) used.
- conclusions and implications of your findings
- areas where further research may be required.

[20]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.