# University of Cambridge Local Examinations Syndicate

# Biomedical Admissions Test

Wednesday      5 November 2003      Morning      30 minutes

## SECTION 2      Scientific Knowledge and Applications

**Instructions to Candidates**

**Please read this page carefully, but do not open the question paper until you are told that you may do so.**

A separate answer sheet is provided for this section. Please check you have one. You also require a soft pencil and an eraser.

Please first write your name, date of birth, Biomedical Admissions Test candidate number and UCAS number (if known) in the spaces provided on the answer sheet. Please write very clearly.

Please also write your BMAT candidate number in the space below.

**BMAT Candidate Number**

Speed as well as accuracy is important in this section. ***Work quickly, or you may not finish the paper.*** There are no penalties for incorrect responses, only points for correct answers, so you should attempt all 29 questions.
Unless otherwise stated, all questions are worth one mark.

Answer on the sheet provided. Many questions ask you to show your choice between options by shading a circle (or circles, if specified in the question).
If questions ask you to write in words or numbers, be sure to write clearly in the spaces provided. If you make a mistake, erase thoroughly and try again.

Any rough work should be done on this question paper.

Calculators are NOT permitted.

**Please wait to be told you may begin before turning this page.**

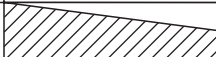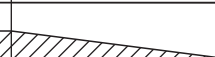*This paper consists of 13 printed pages and 3 blank pages.*
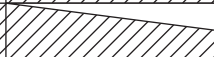
**The questions in this paper that are marked with an asterisk (\* Qs: 4, 8, 13, 19, 21, 22) assume knowledge that is not currently on the BMAT specification.**

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1    The table below shows the proportions of undigested and digested carbohydrates, fats and proteins in three regions of the digestive system.

| type of nutrient | mouth | stomach | small intestine |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

Key

▨ undigested food

☐ digested food

Which row of the table below correctly identifies the types of nutrient **1**, **2** and **3**?

| | 1 | 2 | 3 |
|---|---|---|---|
| **A** | protein | fat | starch |
| **B** | starch | protein | fat |
| **C** | protein | starch | fat |
| **D** | fat | protein | starch |
| **E** | starch | fat | protein |
| **F** | fat | starch | protein |

2    The mass of an atom of uranium is $4 \times 10^{-25}$ kg.

What is the mass, in milligrams, of 8 million atoms of uranium?

**A**    $3.2 \times 10^{-18}$

**B**    $3.2 \times 10^{-17}$

**C**    $3.2 \times 10^{-16}$

**D**    $3.2 \times 10^{-15}$

**E**    $3.2 \times 10^{-12}$

3    What values of $a$, $b$ and $c$ are needed to balance the equation?

$$a\text{C}_3\text{H}_6 + b\text{O}_2 \rightarrow 6\text{CO}_2 + c\text{H}_2\text{O}$$

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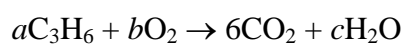
**\* 4** The diagram shows a uniform beam pivoted at its centre. The bar weighs 800N, and three other forces act on it as shown. Distance *x* can be varied.
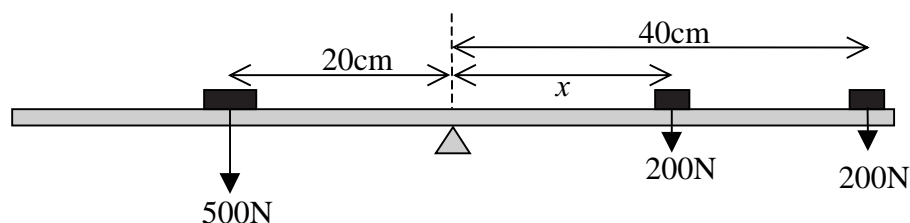


What value of distance *x* would cause the beam to be balanced?

**A**  5 cm

**B**  10 cm

**C**  20 cm

**D**  30 cm

**E**  40 cm

**5** The colours of three indicators are shown.

| indicator | colour at | | pH at which colour change takes place |
|---|---|---|---|
| | low pH | high pH | |
| methyl orange | red | yellow | 4.0 |
| bromothymol blue | yellow | blue | 6.5 |
| phenolphthalein | colourless | pink | 9.0 |

Equal volumes of these three indicators were mixed and the mixture was added to a solution of pH 5.0. What colour would be seen?

**A**  blue

**B**  green

**C**  orange

**D**  yellow

**6** A horse of weight 6000 N gallops at a speed of 16 m/s. Taking the acceleration of free fall as 10 m/s$^2$, calculate the kinetic energy of the horse. (Give your answer in kJ.)

**7**    The diagram shows the menstrual (oestrus) cycle for a human female who is not pregnant.
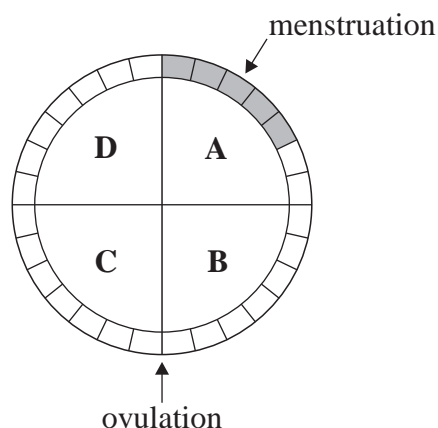


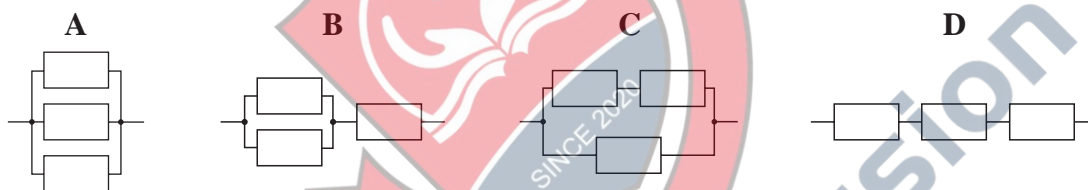During which period, **A**, **B**, **C** or **D**, will the concentration of oestrogen reach its highest level?

**\* 8**    Three resistors of equal value are connected up as shown.



Arrange the letters corresponding to the four combinations in increasing order of resistance (least resistance first).

**9**    Ammonia is manufactured from the reaction between nitrogen and hydrogen.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

What is the maximum mass of ammonia that can be obtained from a mixture of 56 g of nitrogen with 9 g of hydrogen?  (Relative atomic masses: H = 1; N = 14.)

**A**    34 g

**B**    51 g

**C**    65 g

**D**    68 g

**10**  Which **one** of these graphs could be a sketch of the graph of the function $y = 2^x$ ?
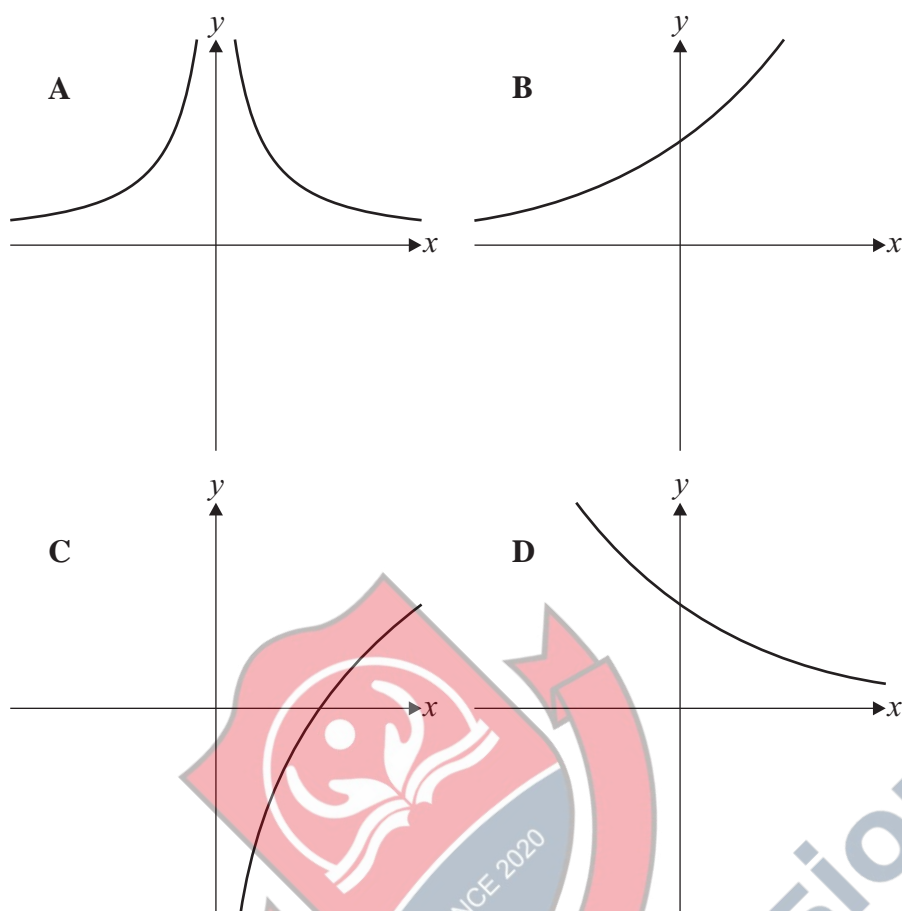


**11**  Three of the characteristic phenomena demonstrated by waves are reflection, refraction and diffraction.
How many of these phenomena cause the frequency of the wave to change?

**A**   0

**B**   1

**C**   2

**D**   3

**12**  In the citric acid cycle, succinic acid, $C_4H_6O_4$, is converted into fumaric acid, $C_4H_4O_4$.  This is an example of which **one** of the following chemical changes?

**A**   oxidation

**B**   reduction

**C**   neutralisation

**D**   dehydration

**\* 13** Solve the inequality

$$x^2 \geq 8 - 2x$$

**A**    $x \geq 4$

**B**    $x \leq 2$  and  $x \geq -4$

**C**    $x \geq -2$  and  $x \leq 4$

**D**    $x \geq 2$  or  $x \leq -4$

**14**    The diagram shows the inheritance of a condition in a family.



Key
- ○ female unaffected
- ● female with condition
- □ male unaffected
- ■ male with condition
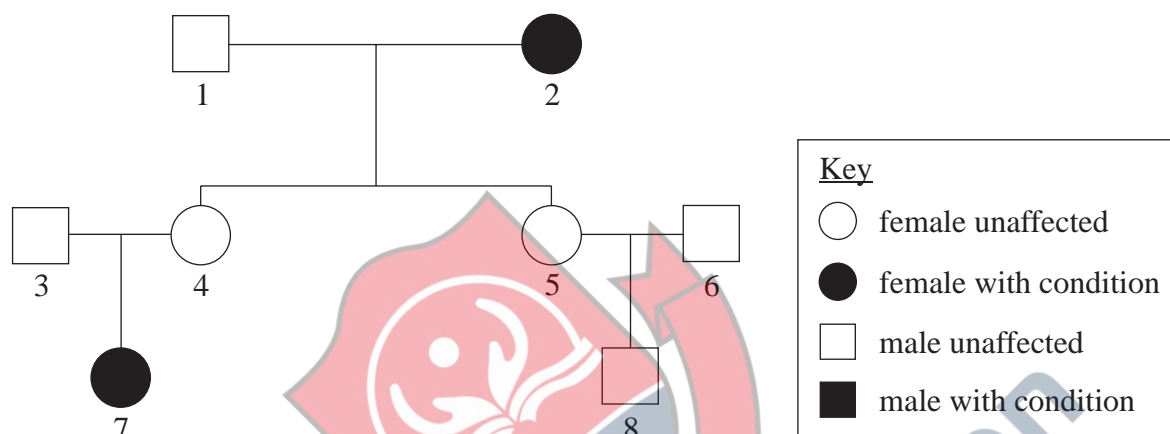
(i)    Identify the three individuals who **must** be heterozygous for this condition.

(ii)    What are the chances that a second child of individuals 3 and 4 will be a female who has this condition?

**A**    1 in 1   (100%)

**B**    1 in 2   (50%)

**C**    1 in 3   (33.3%)

**D**    1 in 4   (25%)

**E**    1 in 8   (12.5%)

[2 marks]

**15**    In an experiment concerning radioactive decay, the count rate of radiation 5 cm from a source **X** was measured as 140 counts per minute.  12 minutes later, with the detector in the same position, the count rate was measured as 35 counts per minute.

Background radiation was recorded as 20 counts per minute.

Calculate the half-life of source **X**.  (Give your answer in minutes.)

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**16** The graph shows the solubility of potassium chlorate(V).
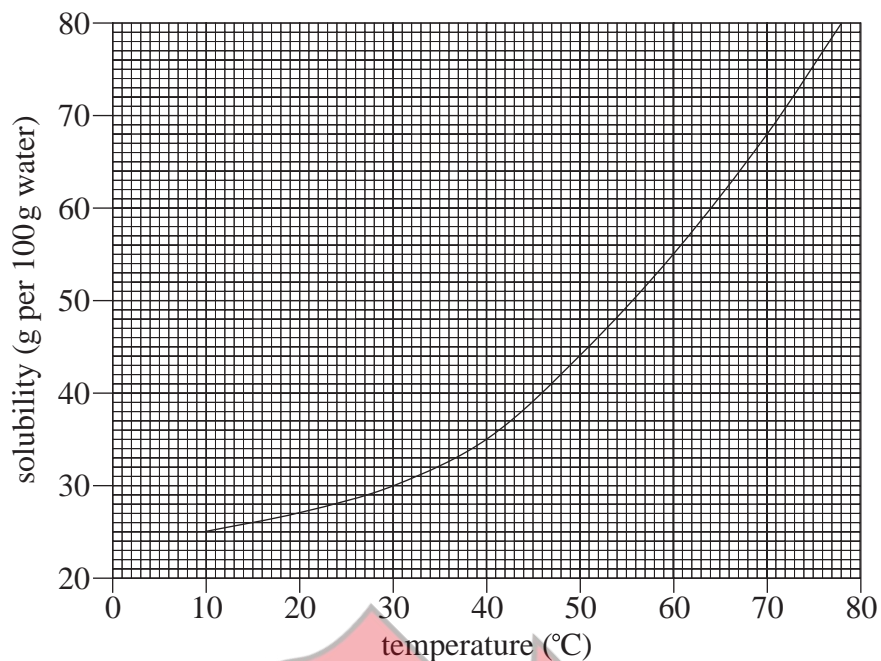


A sample of potassium chlorate(V) weighing 80 g was added to 200 g of water at 70 °C.
The solution was allowed to cool to 20 °C.
What mass of crystals was formed?

**A**   80 g

**B**   40 g

**C**   26 g

**D**   17 g

**E**   13 g

**17** Which **one** of the following is **not** equal to volts?

**A**   $\dfrac{\text{joules}}{\text{coulombs}}$

**B**   $\text{amperes} \times \text{ohms}$

**C**   $\dfrac{\text{watts}}{\text{amperes}}$

**D**   $\sqrt{\text{watts} \times \text{ohms}}$

**E**   $\sqrt{\dfrac{\text{watts}}{\text{coulombs}}}$

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**18** The antidiuretic hormone (ADH) is produced by the pituitary gland and its target organ is the kidney. ADH leaves the head in the jugular vein.
In what order will the hormone pass through the following blood vessels to reach its target?

    **A**    aorta
    **B**    pulmonary artery
    **C**    pulmonary vein
    **D**    renal artery
    **E**    vena cava

**\* 19** The energy in joules ($E$) associated with a photon of radiation is related to its frequency in hertz ($f$) by the equation: $f = {}^{E}/_{h}$ where h is a constant ($6.63 \times 10^{-34}$). What is the energy of a photon of radiation if 5 waves of this radiation are produced in $1 \times 10^{-13}$ sec?

    **A**    $1.33 \times 10^{-21}$ J

    **B**    $6.63 \times 10^{-21}$ J

    **C**    $3.32 \times 10^{-20}$ J

    **D**    $1.51 \times 10^{46}$ J

    **E**    $7.54 \times 10^{46}$ J

**20** The electronic configuration of an isolated, non-ionised, atom is shown below:
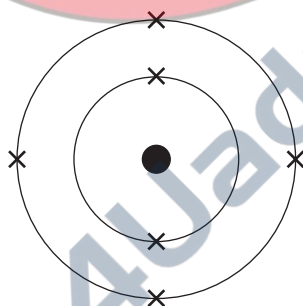


In which group and in which period of the periodic table is this atom situated?

| | group | period |
|---|---|---|
| **A** | 2 | 4 |
| **B** | 2 | 6 |
| **C** | 4 | 2 |
| **D** | 4 | 6 |
| **E** | 6 | 2 |
| **F** | 6 | 4 |

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**\* 21**   Diagrams **1** to **5** show five types of levers.

**1**

effort

load        fulcrum

**2**

load

effort        fulcrum

**3**

effort        fulcrum

load

**4**

effort        fulcrum        load

**5**

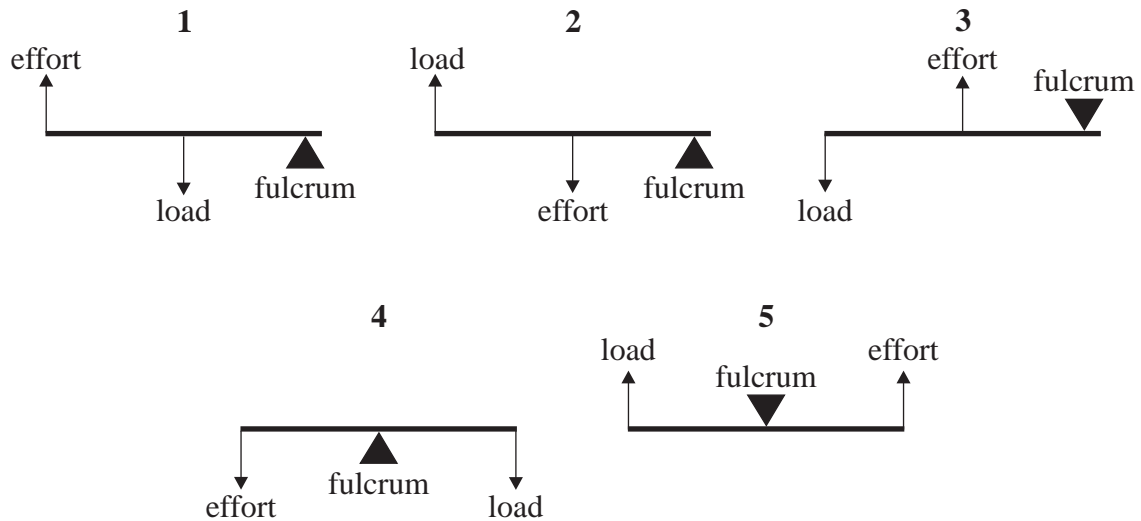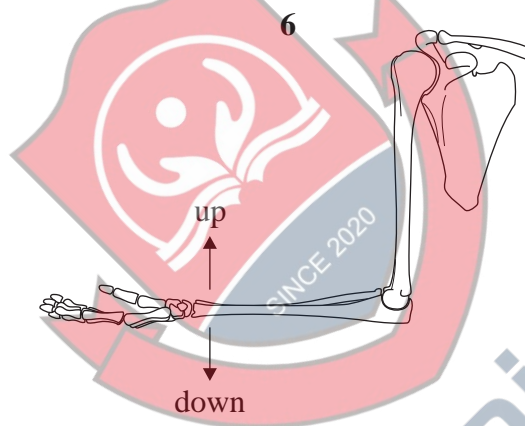load        fulcrum        effort

Diagram **6** shows the bones of the arm with arrows showing its movement up and down.

**6**

up

down

Which two levers would be involved in the forcible up and down movement?

|       | up  | down |
|-------|-----|------|
| **A** | 1   | 2    |
| **B** | 1   | 3    |
| **C** | 2   | 3    |
| **D** | 3   | 4    |
| **E** | 3   | 5    |
| **F** | 5   | 2    |

**\* 22** In an a.c. generator driving a resistive load a coil is rotated slowly between the poles of a magnet. Which of the following will increase if the coil is rotated more quickly?

1 the frequency of the a.c.
2 the amplitude of the a.c.
3 the output e.m.f. of the generator

**A** 1

**B** 1 and 2

**C** 1 and 3

**D** 2 and 3

**E** 1, 2 and 3

**23** The reactivity of the alkali metals (group 1) increases as the atomic number increases. Which **one** of these statements is the correct explanation of this fact?

**A** The atoms have only one electron in the outer orbit / energy level.

**B** They are the most reactive of all the groups of metals in the periodic table.

**C** The number of neutrons in the nuclei increases.

**D** The atomic mass increases.

**E** The outer orbit / energy level is further from the nucleus.

**24** Which set of events occurs during exhalation?

|   | volume of thorax | diaphragm becomes | pressure in thorax | ribs pivot |
|---|---|---|---|---|
| **A** | decreases | more convex | increases | down and outwards |
| **B** | increases | less convex | decreases | up and outwards |
| **C** | decreases | more convex | increases | down and inwards |
| **D** | increases | more convex | decreases | up and inwards |
| **E** | decreases | less convex | increases | down and outwards |
| **F** | increases | less convex | decreases | up and inwards |

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**25** Simplify

$$\left( \frac{2x^{\frac{3}{2}} y^3}{\sqrt{z}} \right)^2$$

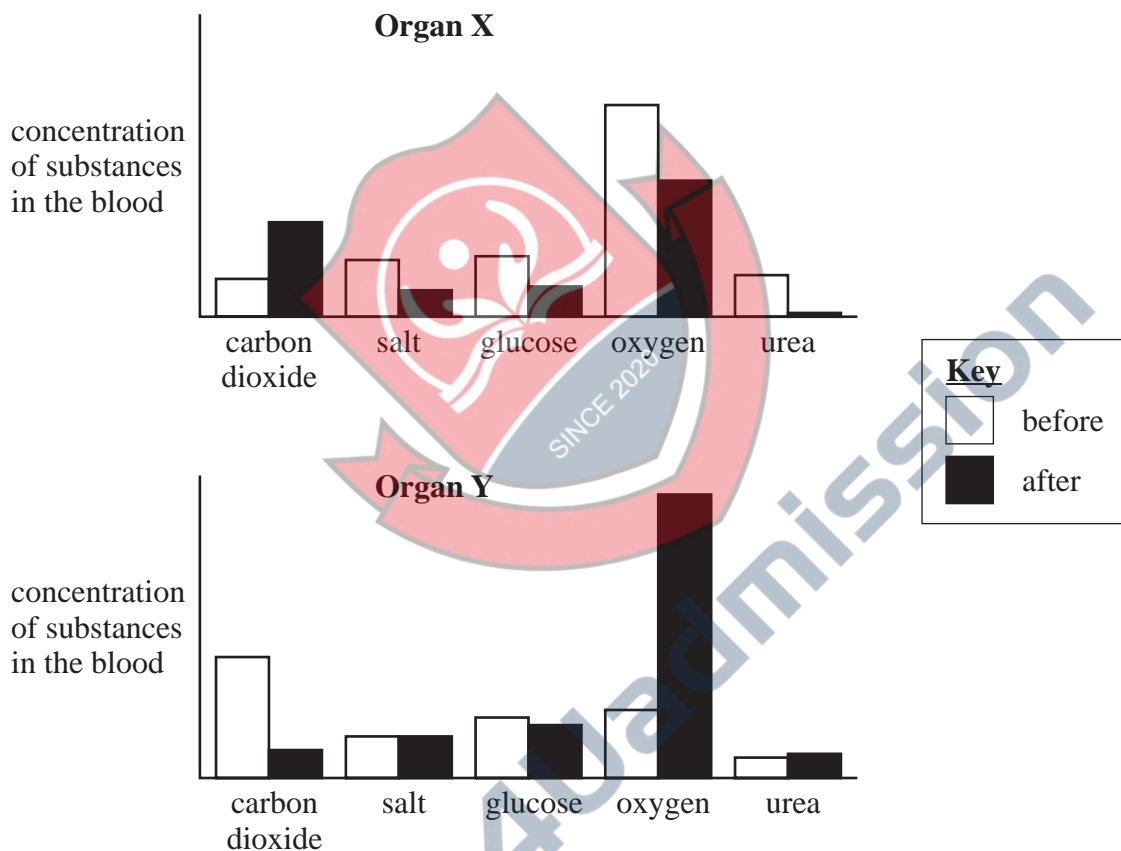| **A** | **B** | **C** | **D** |
|---|---|---|---|
| $\dfrac{4x^6 y^5}{z^2}$ | $\dfrac{4x^3 y^6}{z}$ | $\dfrac{4x^3 y^5}{z}$ | $\dfrac{4x^{\frac{5}{2}} y^5}{z}$ |

**26** The bar charts **X** and **Y** show the concentration of five substances in the blood before and after passing through two organs.



What are the organs **X** and **Y** through which the blood has passed?

| | **X** | **Y** |
|---|---|---|
| **A** | heart | lung |
| **B** | kidney | liver |
| **C** | kidney | lung |
| **D** | liver | kidney |
| **E** | lung | heart |
| **F** | lung | liver |

**27** A parachutist falls from an aircraft and reaches a terminal velocity. After a while he opens his parachute and reaches a new (lower) terminal velocity.

Which graph shows how the air resistance (drag) force acting on him varies with time during the fall?
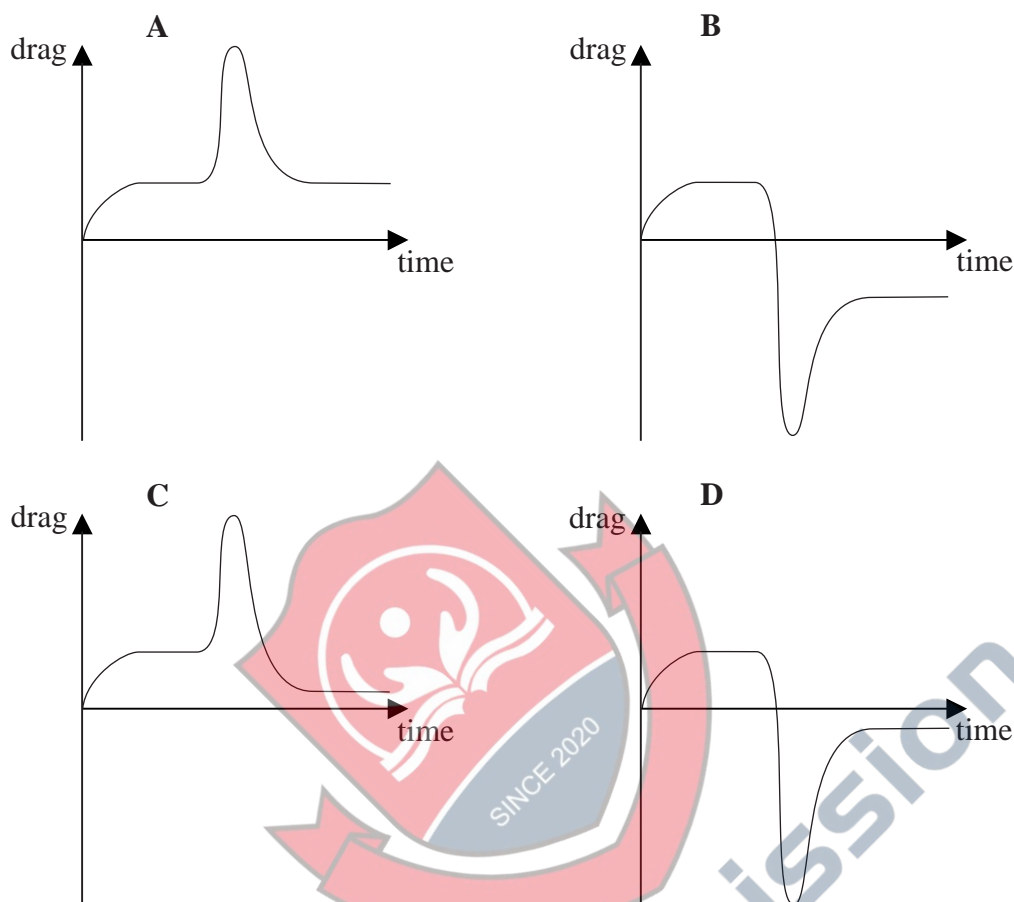


**28** The enamel on teeth treated with fluorine may include fluoroapatite, which contains $Ca^{2+}$, $PO_4^{3-}$ and $F^-$ ions.

Which **one** of the following is a possible formula for fluoroapatite?

**A** $Ca(PO_4)F$

**B** $Ca_3(PO_4)_2F$

**C** $Ca_5(PO_4)_3F$

**D** $Ca_7(PO_4)_5F$

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**29**   In triangle PQR

∠ QPR = 60°
∠ PQR = 45°
∠ QRP = 75°
RQ = $\sqrt{6}$ units
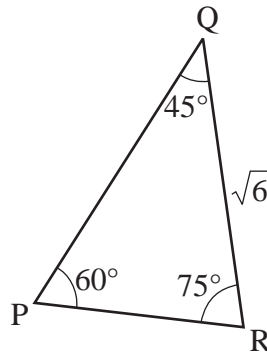


Given that cos 60° is ½, find the length of side PR.  (The diagram is not drawn to scale.)

**A**   2

**B**   $\sqrt{3}$

**C**   $\sqrt{2}$

**D**   $\sqrt{6}$

**END OF SECTION 2**

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