BioMedical Admissions Test 4500/12

November 2021 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.

This paper is Section 2 of 3. Your supervisor will collect this question paper and answer sheet before giving out Section 3.

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

Please complete the answer sheet with your:

- BMAT candidate number
- Centre number
- Date of birth
- Name

Speed as well as accuracy is important in this section. ***Work quickly, or you might not finish the paper***. There are no penalties for incorrect responses, only marks for correct answers, so you should attempt **all** 27 questions. Each question is worth one mark.

Answer on the sheet provided. Questions ask you to show your choice between options by shading one circle. If you make a mistake, erase thoroughly and try again.

You **must** complete the answer sheet within the time limit.

You can use the question paper for rough working or notes, but **no extra paper** is allowed. Only your responses on the answer sheet will be marked.

Calculators are NOT permitted.

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

This question paper consists of 20 printed pages and 4 blank pages.

PV3

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1 A person with cardiovascular disease is at risk of a heart attack. A blood clot may form in one of the arteries that supplies blood to the heart muscle. If the blood clot blocks the artery, blood will be unable to reach some of the cells in the heart. These cells will die due to a lack of oxygen.

Scientists aim to develop a treatment that uses stem cells to replace the cells damaged during a heart attack.

Which of the following statements about cardiovascular disease and possible stem cell treatment after a heart attack is/are correct?

    1   Cardiovascular disease is a communicable disease that is caused by the interaction of many factors.

    2   Embryonic stem cells could be used for this treatment because they can differentiate into muscle cells in the heart.

    3   The treatment to replace damaged cells in the heart with stem cells could increase the risk of cancer developing.

A   none of them

B   1 only

C   2 only

D   3 only

E   1 and 2 only

F   1 and 3 only

G   2 and 3 only

H   1, 2 and 3

2 Element Z forms a stable ion Z^{3-} which has the electron configuration 2,8,8.

To which Group and Period of the Periodic Table does Z belong?

	Group	Period
A	13	2
B	13	3
C	15	2
D	15	3
E	18	2
F	18	3

3   An object of mass 5.0 kg falls vertically through still air. The air resistance acting on the object has a constant value of 50 N.

Which of the following statements about the object is/are correct?

    1   The acceleration of the object is $10\,\mathrm{m\,s^{-2}}$.

    2   There is no resultant force on the object.

    3   The object is travelling at its terminal velocity.

(gravitational field strength $= 10\,\mathrm{N\,kg^{-1}}$)

A   none of them

B   1 only

C   2 only

D   3 only

E   1 and 2 only

F   1 and 3 only

G   2 and 3 only

H   1, 2 and 3

4 Express the following in its simplest form:

$$3xy\left(\frac{x^3}{y^4}\right)^2$$

A $\quad \dfrac{3x^5}{y^5}$

B $\quad \dfrac{9x^5}{y^5}$

C $\quad \dfrac{9x^5}{y^7}$

D $\quad \dfrac{3x^6}{y^7}$

E $\quad \dfrac{3x^7}{y^7}$

F $\quad \dfrac{9x^7}{y^7}$

5   The browning of fruit involves enzymes.

The time taken for slices of apple kept in different solutions to turn brown is shown in the table. The effect of pH and sodium chloride concentration was investigated. All other variables were kept constant.
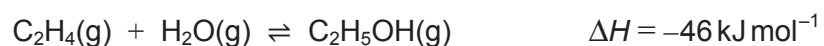
| apple slice | condition | | time taken for the apple to brown / minutes |
	pH	sodium chloride concentration / mol dm^{-3}	
1	3.0	0.0	22
2	5.0	0.0	10
3	7.0	0.0	6
4	9.0	0.0	6
5	7.0	0.5	15

A student used the data to make the following statements about these enzyme-catalysed reactions.

Which of these statements is/are correct?

1   The enzymes involved in browning are denatured in weakly alkaline conditions.

2   The optimum pH for the enzymes is pH 7.0.

3   The enzymes are activated by sodium chloride.

A   none of them

B   1 only

C   2 only

D   3 only

E   1 and 2 only

F   1 and 3 only

G   2 and 3 only

H   1, 2 and 3

6 The industrial manufacture of ethanol from ethene is a catalysed reversible reaction. The equation for this reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -46\,kJ\,mol^{-1}$$

Which of the following changes in conditions, when made independently, would increase the number of moles of ethanol present at equilibrium?

    1 increasing the overall pressure

    2 increasing the temperature

    3 the addition of more catalyst

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

7 A radiation detector on a laboratory bench is switched on when there are no radioactive samples in the laboratory. The count rate displayed by the detector is 24 counts per minute.

A radioactive sample is now placed next to the detector and the count rate displayed is 248 counts per minute.

The sample is left next to the detector for 48 hours, after which time the count rate displayed is 31 counts per minute.

Based on this information, what is the half-life of the sample?

A   1.5 hours

B   6.0 hours

C   8.0 hours

D   9.6 hours

E   12 hours

F   16 hours

8 What is the mean of $\sqrt{12}$, $\sqrt{27}$ and $\sqrt{147}$?

A $\sqrt{27}$

B $\sqrt{48}$

C $\sqrt{62}$

D $\sqrt{80}$

E $\sqrt{186}$

F $\sqrt{432}$

9 A mature active cell in a healthy human has the following features:

- a cell membrane
- no nuclear DNA
- molecules that bind with oxygen.

Which of the following statements about this cell is/are correct?

1 It is transported by a solution.

2 It releases oxygen into active tissues.

3 It releases energy from its own mitochondria.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

10 An inorganic salt was analysed to determine its composition.

The compound gave a lilac flame in a flame test.

After dissolving in water and adding sodium hydroxide solution, a green precipitate was formed.

After dissolving in water, acidifying with dilute hydrochloric acid and adding barium chloride solution, a white precipitate was formed.

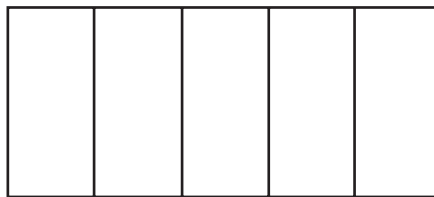Which of the following could be the formula of the salt?

A $LiFeCl_4 \cdot 6H_2O$

B $KFeCl_4 \cdot 6H_2O$

C $Li_2FeCl_4 \cdot 6H_2O$

D $K_2FeCl_4 \cdot 6H_2O$

E $LiFe(SO_4)_2 \cdot 6H_2O$

F $KFe(SO_4)_2 \cdot 6H_2O$

G $Li_2Fe(SO_4)_2 \cdot 6H_2O$

H $K_2Fe(SO_4)_2 \cdot 6H_2O$

11 A solid cuboid has dimensions $0.20\,m \times 0.10\,m \times 0.10\,m$ and density $2000\,kg\,m^{-3}$.

What pressure is exerted by the weight of the cuboid when it rests with the whole of one of its largest faces on horizontal ground?

(gravitational field strength $= 10\,N\,kg^{-1}$)

A $0.80\,Pa$

B $40\,Pa$

C $200\,Pa$

D $400\,Pa$

E $2000\,Pa$

F $4000\,Pa$

12 Five congruent small rectangles are joined, as shown, to form one large rectangle.

[diagram not to scale]

The large rectangle is mathematically similar to each of the small rectangles.
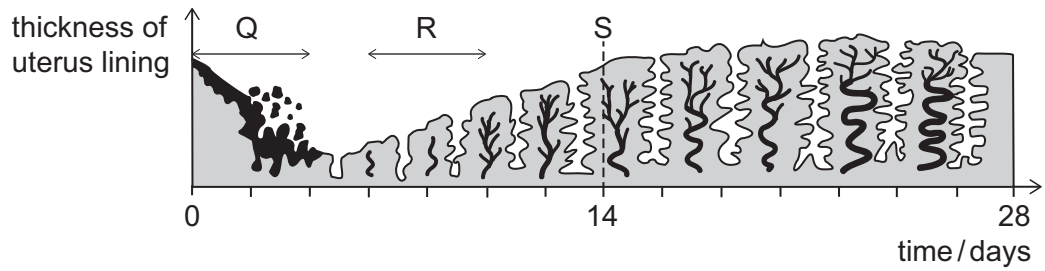
For each small rectangle, find the ratio

length of the shorter side : length of the longer side

A $1 : \sqrt{5}$

B $1 : 2\sqrt{5}$

C $1 : 2.5$

D $1 : 5$

E $1 : 10$

F $1 : 25$

13 The diagram shows changes in the structure of the uterus lining during the menstrual cycle in a healthy female.

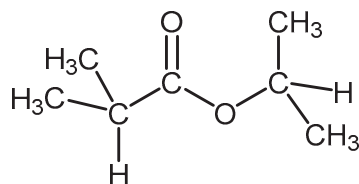Two regions are labelled Q and R. S shows when ovulation occurs.

Which row shows the change in hormone levels responsible for the changes shown in the diagram during Q, during R, and for ovulation at S?

	change in progesterone concentration leading to effect during Q	change in oestrogen concentration leading to effect during R	change in LH concentration at S
A	decrease	increase	increase
B	increase	decrease	decrease
C	decrease	decrease	increase
D	increase	increase	decrease
E	decrease	increase	decrease
F	increase	decrease	increase

14 Carboxylic acids react with alcohols to make esters. A small amount of concentrated sulfuric acid is used as a catalyst.

Consider the following ester:

What is the name of the alcohol that was used to form this ester?

A   butan-1-ol

B   butan-2-ol

C   methylpropan-1-ol

D   methylpropan-2-ol

E   pentan-1-ol

F   pentan-2-ol

G   propan-1-ol

H   propan-2-ol

15 An escalator between two floors in a shop consists of steps that are each 30 cm high and 40 cm deep.

There are 20 steps between the floors.

The escalator moves a person of mass 80 kg upwards from the lower floor to the upper floor.

How much work is done by the escalator on the person?

(gravitational field strength $= 10\,N\,kg^{-1}$)

A   480 J

B   640 J

C   800 J

D   4800 J

E   6400 J

F   8000 J

16 The line with equation $y = -2x + 1$ is reflected in the line with equation $x = 2$

Which of the following is the equation of the new line?

A $y = -\dfrac{1}{2}x - 2$

B $y = -\dfrac{1}{2}x + 1$

C $y = -\dfrac{1}{2}x + \dfrac{7}{4}$

D $y = -\dfrac{1}{2}x + 3$

E $y = 2x - 7$

F $y = 2x - 1$

G $y = 2x + 1$

H $y = 2x + 3$

17 A scientist studying the blue-ringed octopus made the following observations.

- It inhabits shallow coral reefs where water temperatures are between 26 °C and 29 °C.
- It feeds on crabs, shrimp and fish.
- It uses a toxin to paralyse its prey and defend itself from predators.

The toxin used by the blue-ringed octopus is produced by bacteria living in the nutrient-rich environment of the octopus's salivary glands.

Which of the following statements about the blue-ringed octopus is/are correct?

1 Temperature is a biotic factor which restricts where the blue-ringed octopus can live.

2 The relationship between the blue-ringed octopus and the bacteria is an example of mutualism.

3 The blue-ringed octopus and the crabs, shrimp and fish that it eats make up a population of organisms.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

18 Dry air can be cooled and then fractionally distilled to separate its components.

What is the minimum volume of dry air needed to prepare a $25\,dm^3$ sample of oxygen using this method?

(Assume that all volumes are measured at room temperature and pressure, and that all gases are ideal.)

A $32\,dm^3$

B $79\,dm^3$

C $84\,dm^3$

D $119\,dm^3$

E $525\,dm^3$

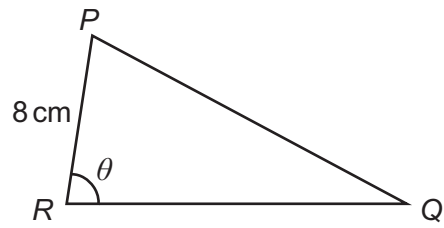19 An electric shower heater is rated at 8.4 kW and raises the temperature of flowing water from 16 °C to 36 °C.

What is the mass of water passing through the shower in a time of 1.0 second?

(specific heat capacity of water = $4200\,J\,kg^{-1}\,°C^{-1}$; assume that all the electrical energy is used to raise the temperature of the water; assume no heat is transferred to the surroundings)

A 5.6 g

B 10.0 g

C 12.5 g

D 56.0 g

E 100 g

F 125 g

20

[diagram not to scale]

The area of triangle *PQR* is 42 cm^2.

The length of *PR* is 8 cm.

$\cos \theta = \dfrac{3}{4}$

What is the length of *QR*, in cm?

A 4.2

B 5.25

C 7

D $3\sqrt{7}$

E 8.4

F 10.5

G 14

H $6\sqrt{7}$

21 A nucleotide consists of three different sub-units.

A section of double-stranded DNA consists of 600 of these sub-units in total. Of these sub-units, 28 are the base adenine.

What percentage of the sub-units of this section of DNA is guanine?

(Assume no mutations.)

A 3.67%

B 4.67%

C 12%

D 14%

E 24%

F 36%

G 45%

22 Three elements from Group 1 and three elements from Group 17 are given in the table with their relative atomic masses.

Group 1	Group 17
lithium (7)	fluorine (19)
sodium (23)	chlorine (35.5)
potassium (39)	bromine (80)

Of the elements in the table, one mole of the most reactive Group 1 element is reacted with one mole of the Group 17 element with the highest boiling point.

What is the maximum mass of the salt formed by this reaction?

A 58 g

B 87 g

C 116 g

D 119 g

E 174 g

F 199 g

G 238 g

23 A high-voltage dc overhead cable carries a current of 2000 A.

One 20 m section of the cable has a mass of 120 kg. This cable section is supported so that it is horizontal, with the current in the direction from west to east.

The Earth's magnetic field in this location is 5.0×10^{-5} T due north and is horizontal.

What is the magnitude of the total force exerted by the support on this section of cable?

(gravitational field strength $= 10\,\text{N}\,\text{kg}^{-1}$)

A 1.0 N

B 2.0 N

C 5.0 N

D 1198 N

E 1200 N

F 1202 N

24 A circle is drawn with centre $(3, 5)$.

A tangent is drawn to the circle.

The tangent touches the circle at the point $(6, 7)$.

What is the gradient of this tangent to the circle?

A -2

B $-\dfrac{3}{2}$

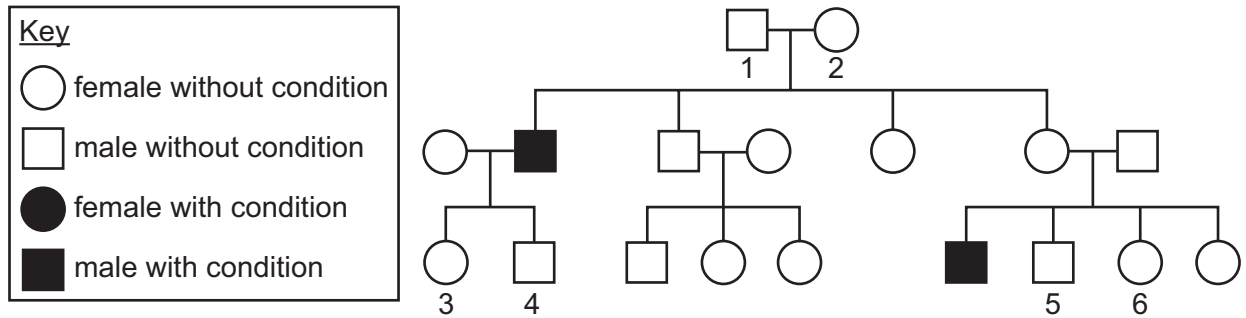**C** $-\dfrac{2}{3}$

D $-\dfrac{1}{2}$

E $\dfrac{1}{2}$

F $\dfrac{2}{3}$

G $\dfrac{3}{2}$

H 2

25 The family tree shows the inheritance of a recessive condition.

Which of the following statements is/are correct?

1 Individuals 1 and 2 are both heterozygous for this condition.

2 Individuals 3 and 4 are both heterozygous for this condition.

3 Individuals 5 and 6 each have a 50% chance of being heterozygous for this condition.

(Assume no new mutations occur.)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

26 Calcium nitride, Ca_3N_2, reacts with water to form calcium hydroxide and molecule X. No other products are formed, and molecule X contains only nitrogen and hydrogen atoms.

What is the empirical formula of X?

A NH

B NH_2

C NH_3

D N_2H_3

E N_2H_4

F N_2H_6

G N_4H_3

27 A train is sounding its horn as it approaches a station. The engine driver hears a note of frequency f_0 and of constant amplitude as the train slows down and stops next to a platform.

A person standing at the end of the platform ahead of where the train stops also hears the sound produced by the horn.

What happens to the amplitude and to the frequency of the sound heard by the person as the train slows down and stops?

	amplitude	frequency
A	decreases	decreases from f_0
B	decreases	decreases to f_0
C	decreases	increases from f_0
D	decreases	increases to f_0
E	increases	decreases from f_0
F	increases	decreases to f_0
G	increases	increases from f_0
H	increases	increases to f_0

END OF TEST

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