

# X069/201

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NATIONAL  
QUALIFICATIONS  
2006

WEDNESDAY, 17 MAY  
1.00 PM – 3.00 PM

PHYSICS  
INTERMEDIATE 2

## Read Carefully

Reference may be made to the Physics Data Booklet

- 1 All questions should be attempted.

## Section A (questions 1 to 20)

- 2 Check that the answer sheet is for Physics Intermediate 2 (Section A).
- 3 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 4 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.  
Do not change any of these details.
- 5 If any of this information is wrong, tell the Invigilator immediately.
- 6 If this information is correct, **print** your name and seat number in the boxes provided.
- 7 There is **only one correct** answer to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the exam, put the **answer sheet for Section A inside the front cover of your answer book.**
- 10 Instructions as to how to record your answers to questions 1–20 are given on page three.

## Section B (questions 21 to 31)

- 11 Answer the questions numbered 21 to 31 in the answer book provided.
- 12 **All answers must be written clearly and legibly in ink.**
- 13 Fill in the details on the front of the answer book.
- 14 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 21 to 31.
- 15 Care should be taken to give an appropriate number of significant figures in the final answers to calculations.



## DATA SHEET

### *Speed of light in materials*

| <i>Material</i> | <i>Speed in m/s</i> |
|-----------------|---------------------|
| Air             | $3.0 \times 10^8$   |
| Carbon dioxide  | $3.0 \times 10^8$   |
| Diamond         | $1.2 \times 10^8$   |
| Glass           | $2.0 \times 10^8$   |
| Glycerol        | $2.1 \times 10^8$   |
| Water           | $2.3 \times 10^8$   |

### *Speed of sound in materials*

| <i>Material</i> | <i>Speed in m/s</i> |
|-----------------|---------------------|
| Aluminium       | 5200                |
| Air             | 340                 |
| Bone            | 4100                |
| Carbon dioxide  | 270                 |
| Glycerol        | 1900                |
| Muscle          | 1600                |
| Steel           | 5200                |
| Tissue          | 1500                |
| Water           | 1500                |

### *Gravitational field strengths*

|         | <i>Gravitational field strength on the surface in N/kg</i> |
|---------|--|
| Earth   | 10   |
| Jupiter | 26   |
| Mars    | 4  |
| Mercury | 4  |
| Moon    | 1.6  |
| Neptune | 12   |
| Saturn  | 11   |
| Sun     | 270  |
| Venus   | 9  |

### *Specific heat capacity of materials*

| <i>Material</i> | <i>Specific heat capacity in J/kg °C</i> |
|-----------------|--|
| Alcohol         | 2350                                     |
| Aluminium       | 902                                      |
| Copper          | 386                                      |
| Glass           | 500                                      |
| Ice             | 2100                                     |
| Iron            | 480                                      |
| Lead            | 128                                      |
| Oil             | 2130                                     |
| Water           | 4180                                     |

### *Specific latent heat of fusion of materials*

| <i>Material</i> | <i>Specific latent heat of fusion in J/kg</i> |
|-----------------|---|
| Alcohol         | $0.99 \times 10^5$                            |
| Aluminium       | $3.95 \times 10^5$                            |
| Carbon dioxide  | $1.80 \times 10^5$                            |
| Copper          | $2.05 \times 10^5$                            |
| Iron            | $2.67 \times 10^5$                            |
| Lead            | $0.25 \times 10^5$                            |
| Water           | $3.34 \times 10^5$                            |

### *Melting and boiling points of materials*

| <i>Material</i> | <i>Melting point in °C</i> | <i>Boiling point in °C</i> |
|-----------------|----------------------------|----------------------------|
| Alcohol         | -98                        | 65                         |
| Aluminium       | 660                        | 2470                       |
| Copper          | 1077                       | 2567                       |
| Glycerol        | 18                         | 290                        |
| Lead            | 328                        | 1737                       |
| Iron            | 1537                       | 2747                       |

### *Specific latent heat of vaporisation of materials*

| <i>Material</i> | <i>Specific latent heat of vaporisation in J/kg</i> |
|-----------------|---|
| Alcohol         | $11.2 \times 10^5$                                  |
| Carbon dioxide  | $3.77 \times 10^5$                                  |
| Glycerol        | $8.30 \times 10^5$                                  |
| Turpentine      | $2.90 \times 10^5$                                  |
| Water           | $22.6 \times 10^5$                                  |

### *Radiation weighting factors*

| <i>Type of radiation</i> | <i>Radiation weighting factor</i> |
|--------------------------|-----------------------------------|
| alpha                    | 20                                |
| beta                     | 1                                 |
| fast neutrons            | 10                                |
| gamma                    | 1                                 |
| slow neutrons            | 3                                 |

## SECTION A


For questions 1 to 20 in this section of the paper the answer to each question is either A, B, C, D or E. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided—see the example below.

### EXAMPLE

The energy unit measured by the electricity meter in your home is the


- A kilowatt-hour
- B ampere
- C watt
- D coulomb
- E volt.

The correct answer is **A**—kilowatt-hour. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).

 **A**   **B**   **C**   **D**   **E**  
=   =   =   =   =

### Changing an answer

If you decide to change your answer, carefully erase your first answer and, using your pencil, fill in the answer you want. The answer below has been changed to **E**.

**A**   **B**   **C**   **D**   **E**   
=   =   =   =   =

[Turn over

## SECTION A

Answer questions 1–20 on the answer sheet.

1. A car travels with an initial speed of 10 m/s. It now accelerates steadily to 30 m/s in 5 s.

Which row shows the car's acceleration and average speed during this time?

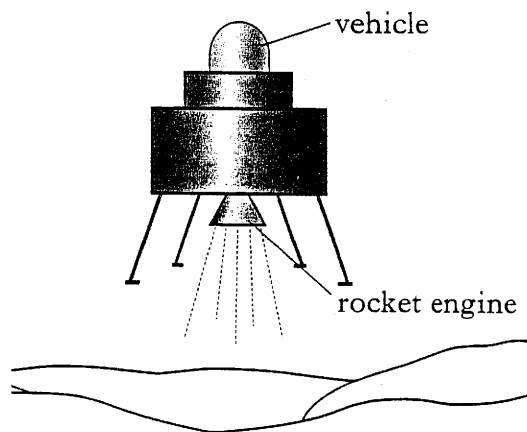
|   | <i>Acceleration</i><br>(m/s <sup>2</sup> ) | <i>Average Speed</i><br>(m/s) |
|---|--|-------------------------------|
| A | 2  | 10                            |
| B | 2  | 20                            |
| C | 4  | 20                            |
| D | 4  | 30                            |
| E | 8  | 30                            |

2. Which of these physical quantities are equivalent?

- A Mass *and* weight
- B Mass *and* acceleration due to gravity
- C Weight *and* acceleration due to gravity
- D Weight *and* gravitational field strength
- E Acceleration due to gravity *and* gravitational field strength

3. A space vehicle of mass 120 kg is falling vertically towards a planet. The gravitational field strength at this point is 3.5 N/kg.

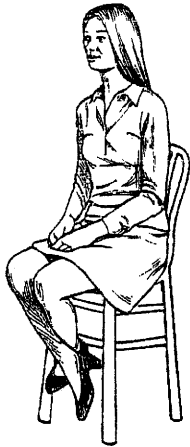
The vehicle fires a rocket engine which applies a steady upward force of 660 N to the vehicle.



Initially the vehicle will

- A move towards the surface, accelerating
- B move towards the surface at steady speed
- C move towards the surface, decelerating
- D move away from the surface, accelerating
- E move away from the surface at steady speed.

4. A person sits on a chair which rests on the Earth. The person exerts a downward force on the chair.

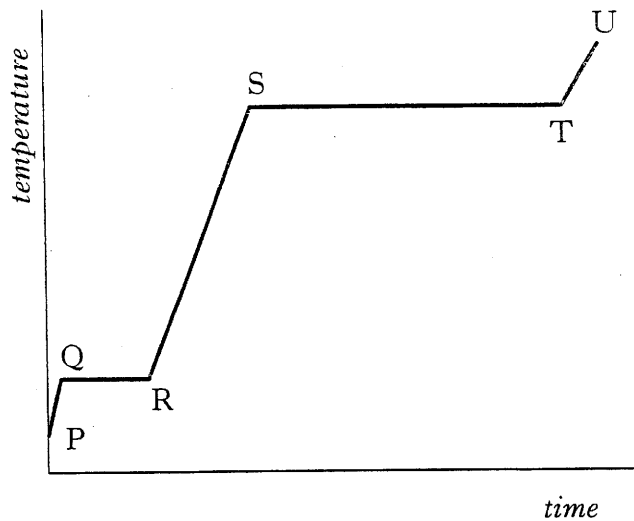


Which of the following is the reaction to this force?

- A The force of the person on the Earth  
 B The force of the person on the chair  
 C The force of the Earth on the person  
 D The force of the chair on the Earth  
 E The force of the chair on the person
5. An electric motor raises a lift of mass 288 kg through a height of 15 m. The input energy to the motor is 54 000 J. The percentage efficiency of the motor is given by

- A  $\frac{288 \times 15 \times 10}{54\,000}$   
 B  $\frac{54\,000 \times 10}{288 \times 15 \times 100}$   
 C  $\frac{288 \times 15 \times 100}{54\,000}$   
 D  $\frac{288 \times 15 \times 10 \times 100}{54\,000}$   
 E  $\frac{54\,000 \times 100}{288 \times 10 \times 15}$

6. A solid substance is placed in an insulated container and heated. The graph shows how the temperature of the substance varies with time.



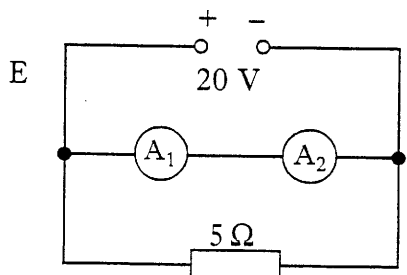
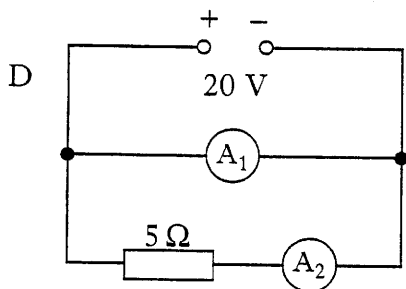
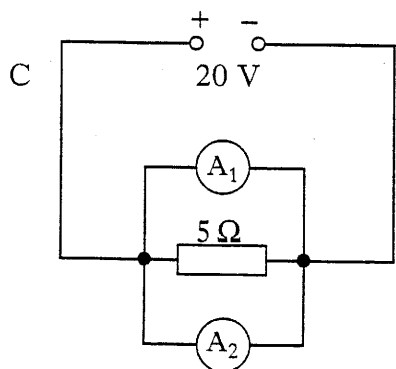
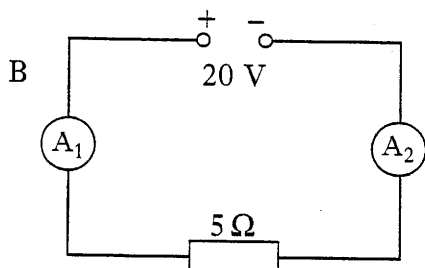
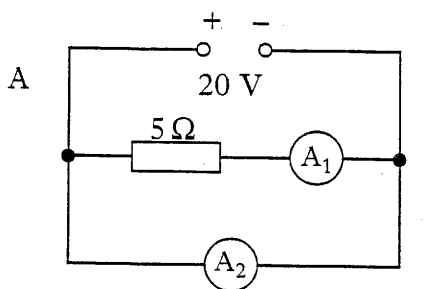
To calculate the specific latent heat of fusion of the substance, a student would use the time from section

- A PQ  
 B QR  
 C RS  
 D ST  
 E TU.
7. Which of the following statements is/are correct?
- I The voltage of a battery is the number of joules of energy it gives to each coulomb of charge.  
 II A battery only has a voltage when it is connected in a complete circuit.  
 III Electrons are free to move within an insulator.
- A I only  
 B II only  
 C III only  
 D II and III only  
 E I, II and III

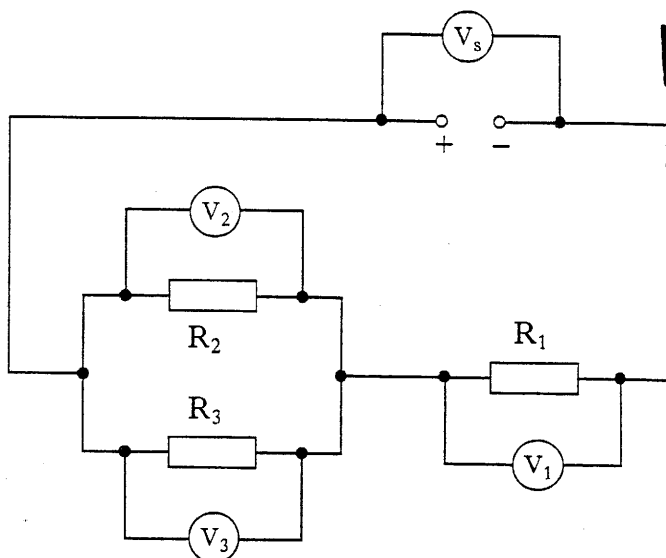
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8. A student suspects that ammeter  $A_1$  may be inaccurate. Ammeter  $A_2$  is known to be accurate.

Which of the following circuits should be used to compare  $A_1$  with  $A_2$ ?



9. A circuit is set up as shown.

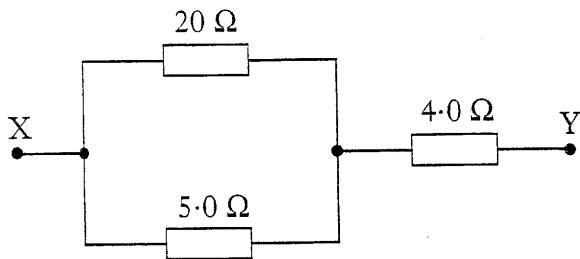


Which of the following statements about the readings on the voltmeters **must always** be true?

- I  $V_1 = V_2$
- II  $V_2 = V_3$
- III  $V_s = V_1 + V_2$

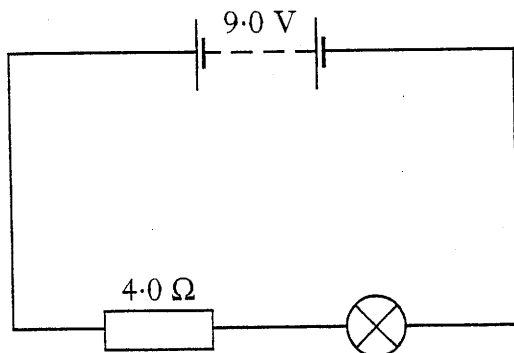
- A II only
- B I and II only
- C I and III only
- D II and III only
- E I, II and III

10. Three resistors are connected as shown.



The resistance between X and Y is

- A 0.5 Ω
  - B 2.0 Ω
  - C 4.25 Ω
  - D 8.0 Ω
  - E 29 Ω.
11. A battery is connected in series to a lamp and resistor as shown.

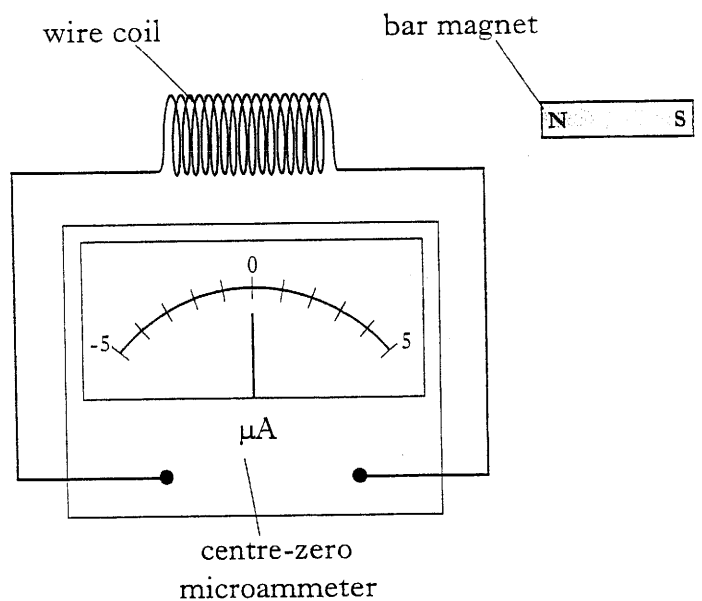


The current in the lamp is 1.5 A.

The power developed in the lamp is

- A 3.0 W
- B 4.5 W
- C 6.0 W
- D 9.0 W
- E 13.5 W.

12. A student investigates the effect of moving a magnet into and out of a coil.



Which of the following statements is/are correct?

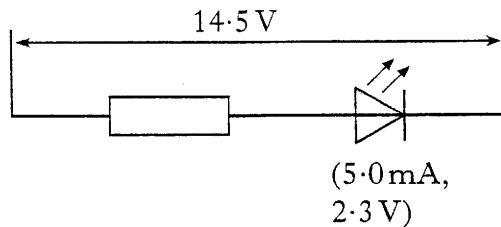
- I When the magnet is moving into the coil, the meter shows a current.
- II The greatest current is measured when the magnet is stationary inside the coil.
- III When the magnet is moving out of the coil, the meter shows no current.

- A I only
- B II only
- C I and II only
- D II and III only
- E I, II and III

[Turn over

13. A light-emitting diode (LED) is used to show that a car windscreen heater is switched on.

The supply voltage is 14.5 V. The current through the LED is 5.0 mA, when the potential difference across it is 2.3 V.



The resistance of the series resistor is

- A 0.46  $\Omega$   
 B 2.90  $\Omega$   
 C 460  $\Omega$   
 D 2440  $\Omega$   
 E 2900  $\Omega$ .
14. An amplifier has a voltage gain of 500. A signal of voltage 3.6 mV and frequency 256 Hz is applied to the input of the amplifier.

Which row shows the voltage and frequency of the signal at the amplifier output?

|   | Voltage     | Frequency |
|---|-------------|-----------|
| A | 7.2 $\mu$ V | 256 Hz    |
| B | 3.6 mV      | 128 kHz   |
| C | 1.8 V       | 256 Hz    |
| D | 1.8 V       | 128 kHz   |
| E | 1800 V      | 256 Hz    |

15. A beam of light has a wavelength of  $4.80 \times 10^{-7}$  m in air. The frequency of this light is

- A  $1.60 \times 10^{-15}$  Hz  
 B  $2.40 \times 10^{-15}$  Hz  
 C  $7.08 \times 10^8$  Hz  
 D  $4.17 \times 10^{14}$  Hz  
 E  $6.25 \times 10^{14}$  Hz.

16. Which of the following statements is/are correct?

- I A long sighted person cannot focus sharply on near objects.  
 II In a short sighted person's eye, rays from a distant object focus behind the retina.  
 III As lens power increases, the focal length decreases.

- A I only  
 B I and II only  
 C I and III only  
 D II and III only  
 E I, II and III

17. A student is asked to write down some types of electromagnetic waves in order of increasing wavelength. The student's answer is **not** correct.

|        |             |          |               |            |
|--------|-------------|----------|---------------|------------|
| X-rays | Ultraviolet | Infrared | Visible light | Microwaves |
|--------|-------------|----------|---------------|------------|

Which **two** of these should be exchanged to make the student's answer correct?

- A X-rays and infrared  
 B Visible light and infrared  
 C Infrared and ultraviolet  
 D Infrared and microwaves  
 E X-rays and microwaves



18. Below are three statements about radiation.

- I The half life of a radioactive source is half of the time it takes for its activity to reduce to zero.
- II The activity of a radioactive source is the number of decays per minute.
- III The risk of harm from radiation is not the same for all types of tissue.

Which statement or statements is/are true?

- A I only
- B II only
- C III only
- D II and III only
- E I, II and III

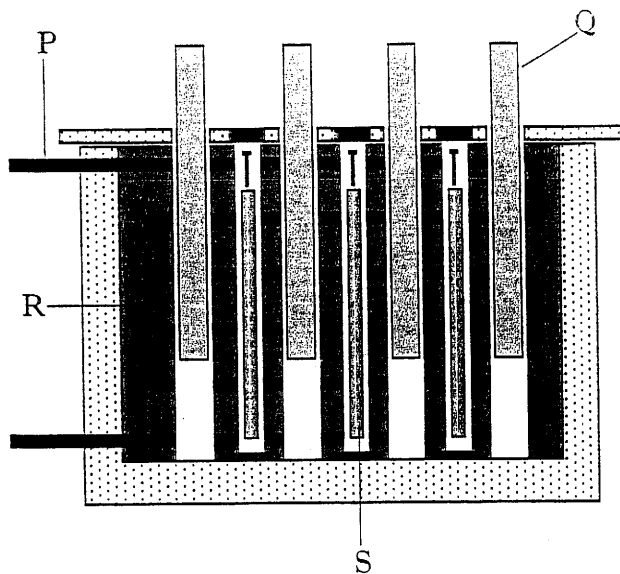
19. A worker in a nuclear power station is accidentally exposed to 3.0 mGy of gamma radiation and 0.50 mGy of fast neutrons.

The radiation weighting factor for gamma radiation is 1 and for fast neutrons is 10.

The total equivalent dose received by the worker, in mSv, is

- A 3.50
- B 8.00
- C 11.0
- D 35.0
- E 38.5.

20. The diagram shows a nuclear reactor in a power station.



Which row shows the parts of the reactor?

|   | P           | Q           | R         | S           |
|---|-------------|-------------|-----------|-------------|
| A | moderator   | fuel rod    | coolant   | control rod |
| B | control rod | moderator   | coolant   | fuel rod    |
| C | moderator   | control rod | coolant   | fuel rod    |
| D | coolant     | control rod | moderator | fuel rod    |
| E | coolant     | fuel rod    | moderator | control rod |

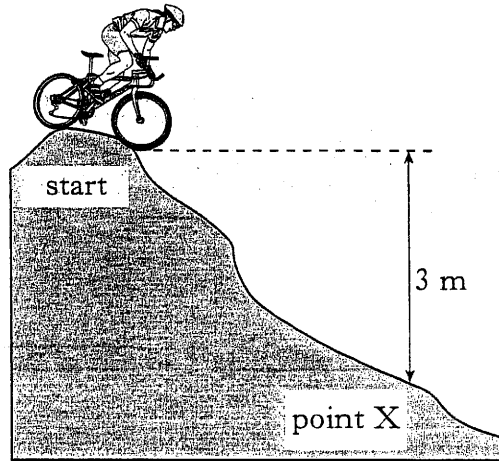
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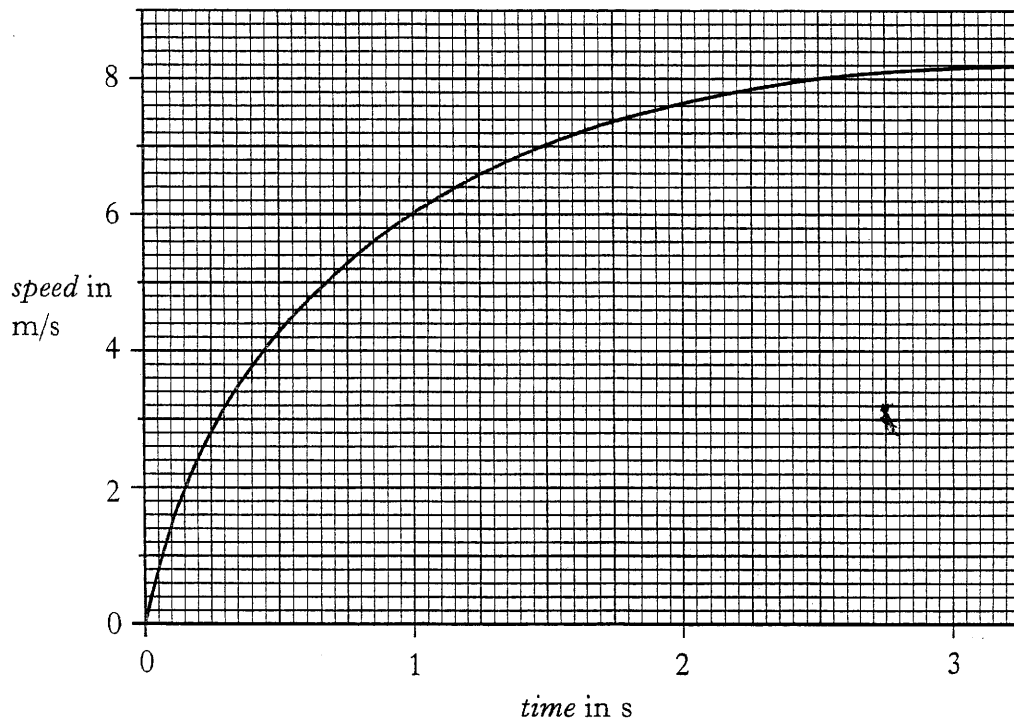
Write your answers to questions 21–31 in the answer book.

All answers must be written clearly and legibly in ink.

21. In a mountain-bike competition, a competitor starts from rest at the top of a hill. He pedals downhill and after 2.5 s he passes point X which is 3 m lower than the start. The total mass of the bike and competitor is 90 kg.



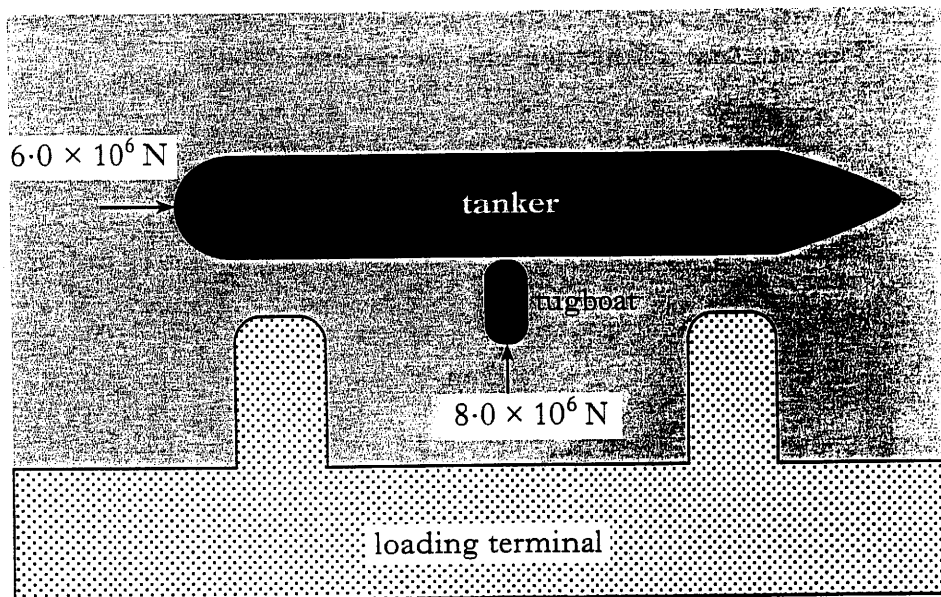
A speed time graph for this part of the competitor's journey is shown below.



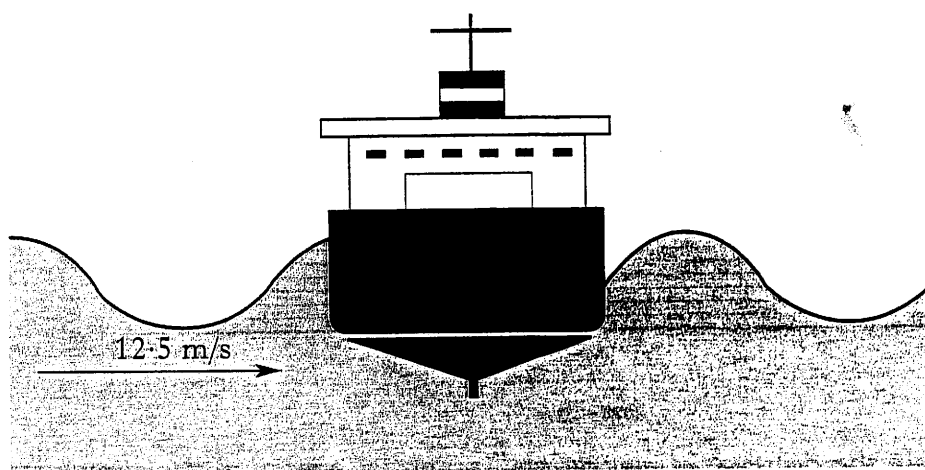
- (a) Calculate the decrease in gravitational potential energy of the competitor and bike between the start and point X. 2
- (b) Calculate the kinetic energy of the competitor and bike at point X. 2
- (c) Explain the difference between your answers to (a) and (b). 2
- (d) (i) What happens to the acceleration of the competitor during the first 2.5 s? 1
- (ii) Explain, in terms of forces, why this happens. 1
- (8)

22. A fully laden oil tanker of mass  $7.5 \times 10^8$  kg leaves a loading terminal.

Its engine and propellers produce a forward force of  $6.0 \times 10^6$  N. A tugboat pushes against one side of the tanker as shown. The tug applies a pushing force of  $8.0 \times 10^6$  N.



- (a) Using a scale diagram or otherwise, find the size of the resultant of these two forces. 2
- (b) Calculate the initial acceleration of the tanker. 2
- (c) Out in the open sea, the side of the tanker is struck by a wave once every 16 s. The speed of the waves is 12.5 m/s.



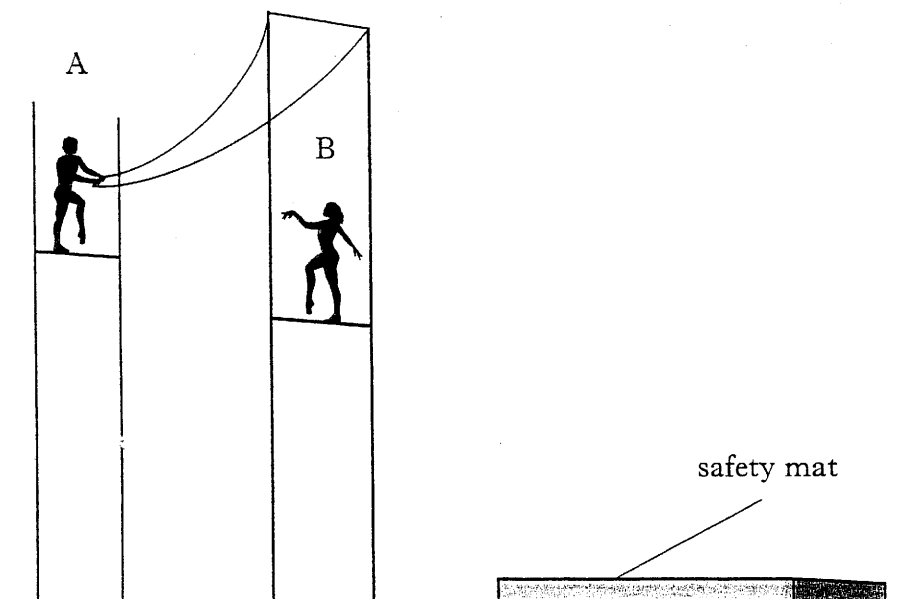
For these waves, calculate:

- (i) the frequency;
- (ii) the wavelength.

1  
2  
(7)

23. In a circus trapeze act, gymnast A has a mass of 60 kg. Gymnast B has a mass of 50 kg.

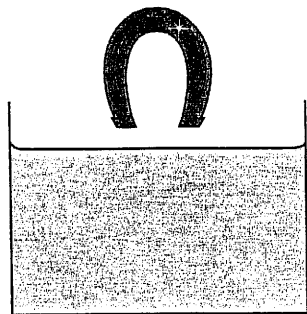
Gymnast A swings down on the trapeze and collides with gymnast B. They move off together at 4.8 m/s.



- (a) Calculate the total momentum of the two gymnasts just after the collision. 2
- (b) Calculate the speed of gymnast A just before the collision. 2
- (c) At the point of collision, gymnast A lets go of the trapeze. At this instant, the pair are travelling horizontally. They fall together for 0.65 s until they land on a safety mat.
- (i) Calculate the horizontal distance they travel until they reach the mat. 2
- (ii) Calculate the **vertical** speed with which they strike the mat. 2
- (8)

[Turn over

24. A blacksmith cools a hot iron horse-shoe of mass 0.75 kg by dropping it into water. The mass of the water is 15 kg and its initial temperature is 17°C. Heat energy from the iron warms the water until both iron and water are at 23°C.

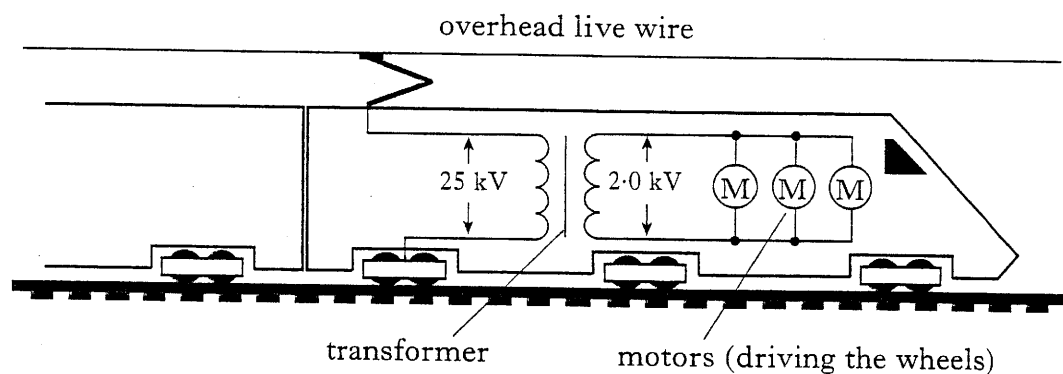


Data on page two will be required for this question.

- (a) Calculate the heat energy absorbed by the water. 2
- (b) Calculate the initial temperature of the horse-shoe. 3
- (c) State **one** assumption required for the calculation in part (b). 1
- (d) What would happen to the temperature rise of the liquid if the blacksmith had replaced the water with the same mass of oil? You **must** explain your answer. 2
- (8)

25. An electric locomotive pulls a car shuttle train through the Channel Tunnel. The maximum power of the locomotive is 7.0 MW.

Current is supplied to the locomotive through an overhead wire at a voltage of 25 kV. A transformer reduces this voltage to 2.0 kV to operate the electric motors. A simplified diagram below shows the circuit.



- (a) The secondary coil of the transformer has 400 turns. Calculate the number of turns on the primary coil. 2
- (b) Calculate the current in the secondary coil when the locomotive is at maximum power. 2
- (c) Over part of the journey the train travels at a steady speed. It covers a distance of 540 m in a time of 15 s.

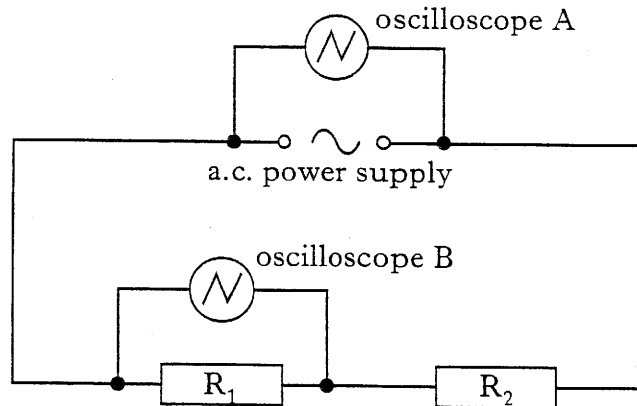
Calculate the maximum pulling force of the locomotive over this part of the journey. 3

(7)

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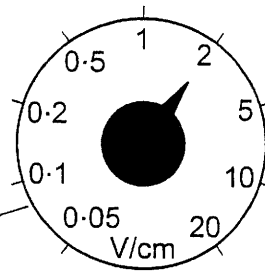
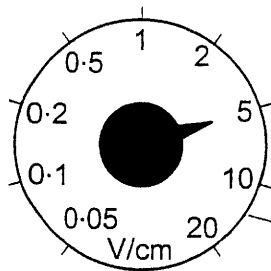
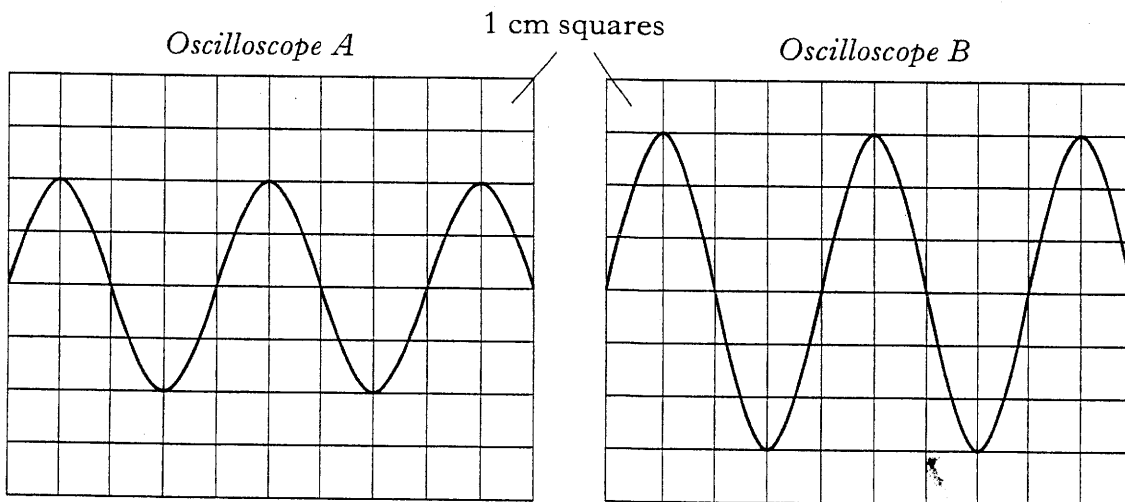
26. (a) Explain the difference between direct current (d.c.) and alternating current (a.c.) in terms of the movement of charges in a conductor.
- (b) A student investigates voltages in the following a.c. circuit, using two oscilloscopes connected as shown.

2



On oscilloscope A, the voltage scale is set at 5 V/cm.

On oscilloscope B, the voltage scale is set at 2 V/cm.



voltage scale settings

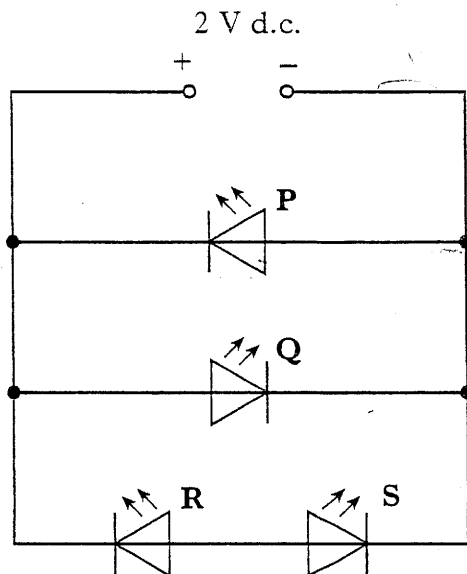
What is the peak voltage across

- (i) the power supply terminals? 1
- (ii) resistor  $R_1$ ? 1
- (iii) resistor  $R_2$ ? 1



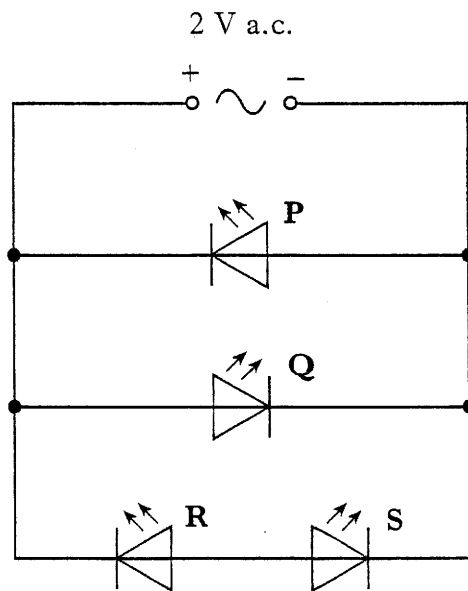
26. (continued)

- (c) How does the quoted value of the a.c. supply voltage compare to your answer in (b)(i)? 1
- (d) The student now connects some LEDs to a 2 V d.c. supply as shown.



Which of the LEDs P, Q, R and S will light? 1

- (e) The student now replaces the 2 V d.c. supply with a 2 V a.c. supply as shown.

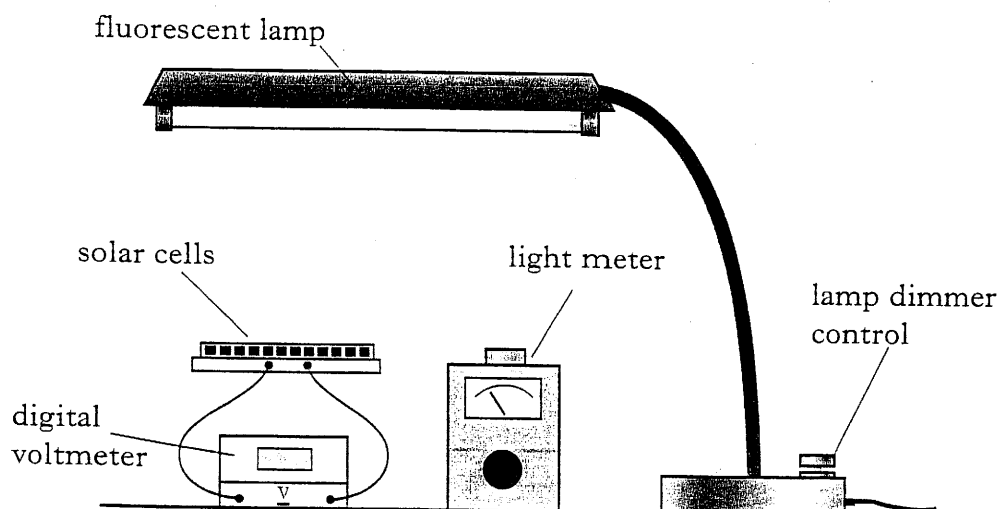


Which LED or LEDs will **now** light? 1

(8)

[Turn over

27. A student investigates solar cells connected in series. She uses a lamp with a dimmer control, a light meter, and a voltmeter as shown.



From her results, the student plots the following graph of the output voltage of the solar cells against the reading shown on the light meter.

