Centre Number

Student Number

SCEGGS Darlinghurst

2007

HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Physics

This is a TRIAL PAPER only and does not necessarily reflect the content or format of the Higher School Certificate Examination for this subject.

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Write your Centre Number and Student Number at the top of this page and page 8.

Total marks – 100

Section I Pages 2–21

75 marks
This section has two parts, Part A and Part B

Part A – 15 marks
- Attempt Questions 1–15
- Allow about 30 minutes for this part

Part B – 60 marks
- Attempt Questions 16–31
- Allow about 1 hour and 45 minutes for this part

Section II Page 22

25 marks
- Attempt Questions 32
- Allow about 45 minutes for this section

Section I
75 marks

Part A – 15 marks
Attempt Questions 1–15
Allow about 30 minutes for this part

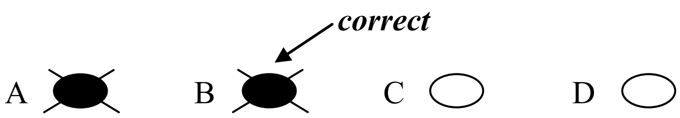
Use the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ***correct*** and drawing an arrow as follows.



1 An experiment was repeated several times in an attempt to measure Earth's gravitational acceleration at the surface of the Earth. The results are shown in the table below:

Trial number	Result (ms^{-2})
1	8.80
2	8.82
3	8.79
4	8.81
5	8.78

It would be true to say that this experiment was:

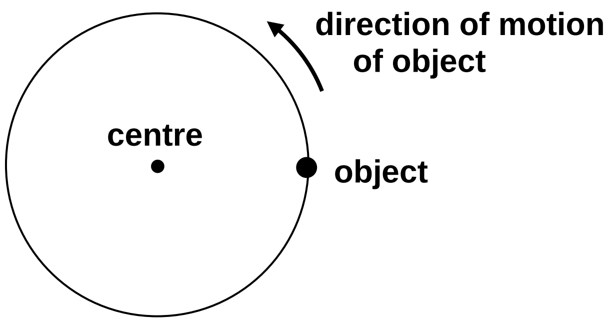
(A) accurate and reliable.

(B) accurate but not reliable.

(C) not accurate but reliable.

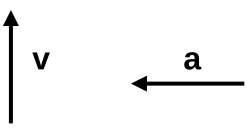
(D) not accurate and not reliable.

2 An object is travelling around in a circular track at a constant speed of 15 ms^{-1}, as shown in the diagram below.

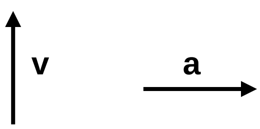


Which vectors best represent the velocity and acceleration of the object at the position shown?

(A)



(B)



(C)

(D)

3 In which of the following situations would you expect the *smallest* escape velocity?

(A) Launching from a 10km high mountain on Earth.

(B) Launching from a planet with half the radius of Earth, but with the same mass.

(C) Launching from a planet with twice the radius of Earth, but with the same mass.

(D) Launching from the bottom of a deep vertical mine shaft.

4 Which of the following could be considered an inertial frame of reference?

(A) A satellite orbiting Earth.

(B) An aircraft accelerating in a straight line.

(C) A spaceship drifting between stars.

(D) A boat bobbing up and down in waves.

5 Any type of AC generator does NOT have:

(A) an armature.

(B) a rotor.

(C) slip rings.

(D) a split-ring commutator.

6 In comparing step-up to step-down transformers, it is true to say that:

(A) the ratio $\frac{n_p}{n_s}$ for step down transformers is always less than in step-up transformers.

(B) the ratio $\frac{n_p}{n_s}$ for step-up transformers is always less than in step-down transformers.

(C) step-up transformers are more efficient than step-down transformers.

(D) step-up transformers are always larger than step-down transformers.

7 Electrical energy is transformed into many different types of useful energy in the home.

Of the transformations listed, which would be most unlikely to be found in the home?

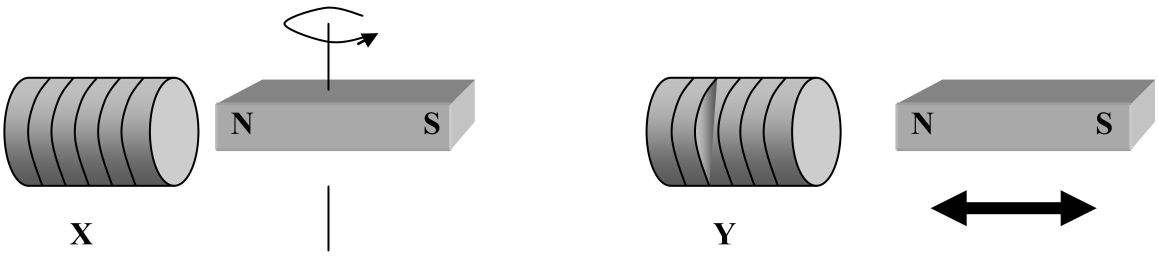
(A) electrical → sound

(B) electrical → chemical

(C) electrical → electromagnetic

(D) electrical → nuclear

8 A bar magnet placed at one end of a solenoid "**X**" was spun on an axle drilled through its mid-point, as shown. An identical bar magnet was also moved backwards and forwards close to the end of an identical solenoid, "**Y**". The second bar magnet completed one back and forth motion to every one rotation of the other magnet.



When the EMF in the coils of the solenoids was displayed on a CRO, it was found that:

(A) the graphs of the EMFs had the same general shapes.

(B) the graph of solenoid **X** had twice the frequency of the graph for solenoid **Y**.

(C) the graph for solenoid **X** was much smoother than the graph for solenoid **Y**.

(D) the graphs were a sine wave shape for solenoid **X** and a square wave shape for solenoid **Y**.

9 The main advantage of AC induction motors over other motors such as the universal motor is that AC induction motors:

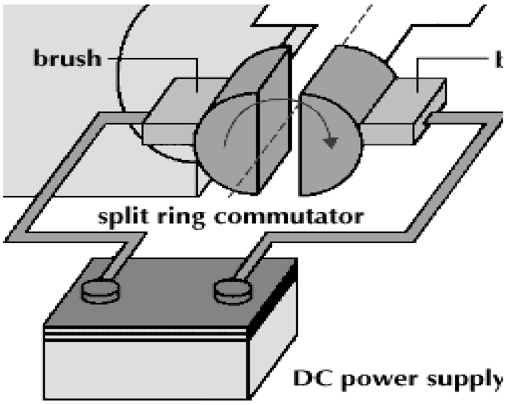
(A) can produce more torque.

(B) can be made much smaller.

(C) do not have brushes that wear out.

(D) can rotate faster.

10 In this diagram of part of a DC motor, the function of the brush is to:



(A) ensure the power supply connects to the commutator ring, even when it is turning.

(B) reverse the direction of the current through the coil.

(C) provide a braking force on the commutator.

(D) ensure that the power supply does not get short-circuited.

11 A circular loop of wire is held horizontally. It is then rotated about a north-south oriented horizontal axis.

The EMF generated would be greatest in which of the following scenarios:

(A) at the equator.

(B) at the south pole.

(C) at the equator, but with an east-west orientation for the axis.

(D) at the equator, but rotated about a vertical axis.

12 The results of Thomson's charge to mass ratio experiments for cathode ray particles showed that they had:

(A) very little mass but moved very quickly.

(B) a charge of one electron.

(C) a small charge to mass ratio.

(D) a large charge to mass ratio.

13 The energy E of photons is graphed against their frequency, f. The gradient of the graph produced:

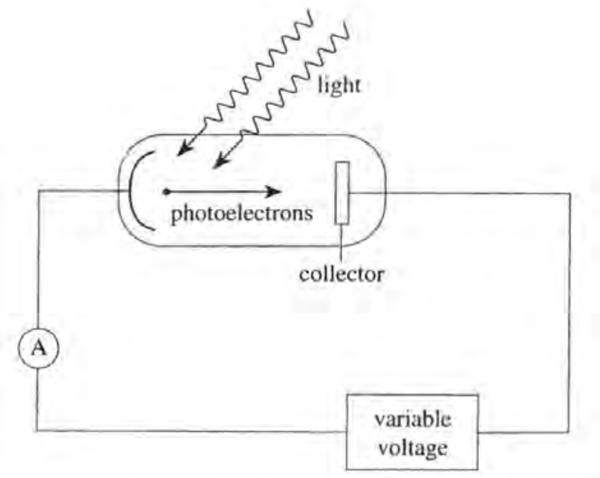
(A) gives the mass of the photons.

(B) is known as Planck's constant.

(C) varies so cannot be measured.

(D) gives the speed of the photons.

14 A beam of light is shone onto a cathode as shown in the diagram below.



Which of the following will increase the number of photoelectrons?

(A) increasing the intensity of the light

(B) decreasing the intensity of the light

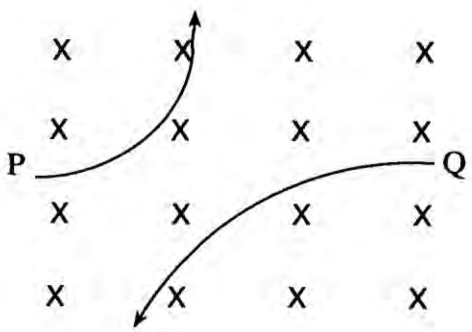
(C) increasing the frequency of the light

(D) decreasing the frequency of the light

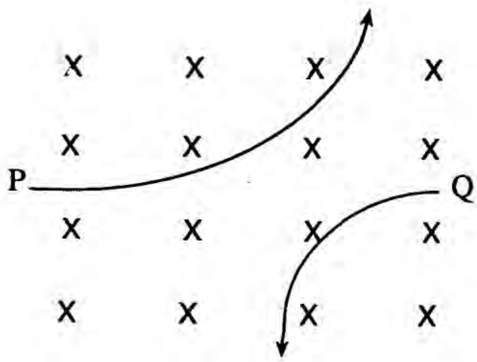
15 Two positively charged particles, P and Q, of equal mass and speed enter a uniform magnetic field directed into the page as shown in the diagram below. Particle Q has **twice** the magnitude of charge as P.

Which diagram correctly represents the subsequent paths of both particles?

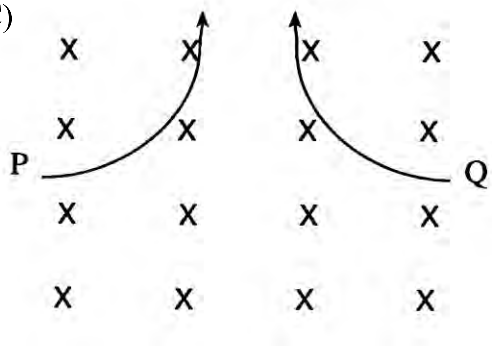
(A)



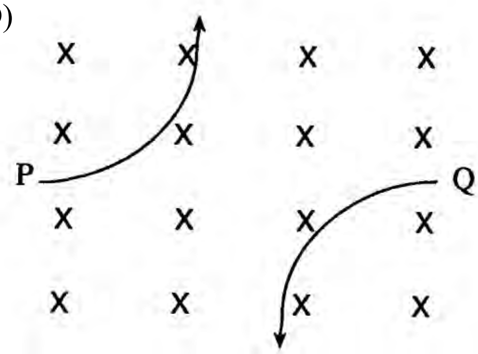
(B)



(C)



(D)



Centre Number

Student Number

Section I (continued)

Part B – 60 marks
Attempt Questions 16–31
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Marks

Question 16 (5 marks)

A 200 kg satellite is orbiting the Earth of radius 6400 km with an altitude of 800 km.

(a) Calculate the gravitational force between the satellite and Earth. **3**

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(b) Determine the orbital speed of this satellite. **2**

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Marks

Question 17 (3 marks)

Explain why launch facilities for putting satellites into Earth orbit are usually located close to the equator. **3**

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Question 18 (4 marks)

Old standards for length used a metal rod kept safely so that it could be compared. **4**

Since 1983, however, the definition of the metre has been:

"*The metre is the length of the path travelled by light in a vacuum during a time interval of 1/299 792 458 of a second.*".

With reference to the principle of relativity, discuss the need for this change to the definition of length.

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Question 19 (4 marks)

A projectile is launched at 52 ms^{-1} at an angle of 35° above the horizontal.

(a) Calculate the range of the projectile 4.0 s after its launch. **1**

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(b) Calculate the speed of the projectile at this time. **3**

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Question 20 (2 marks)

The Michelson-Morley experiments failed to prove the existence of the aether, despite many further attempts with modified designs by other scientists. **2**

Outline why Michelson and Morley believed that if the aether existed, it could be detected using their apparatus.

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Marks

Question 21 (4 marks)

(a) Quantitatively compare the mass of an electron at rest with an electron moving with a velocity of 0.98c. **2**

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(b) What significance does this result have for particle accelerators, which can accelerate particles to speeds approaching 0.9999c? **2**

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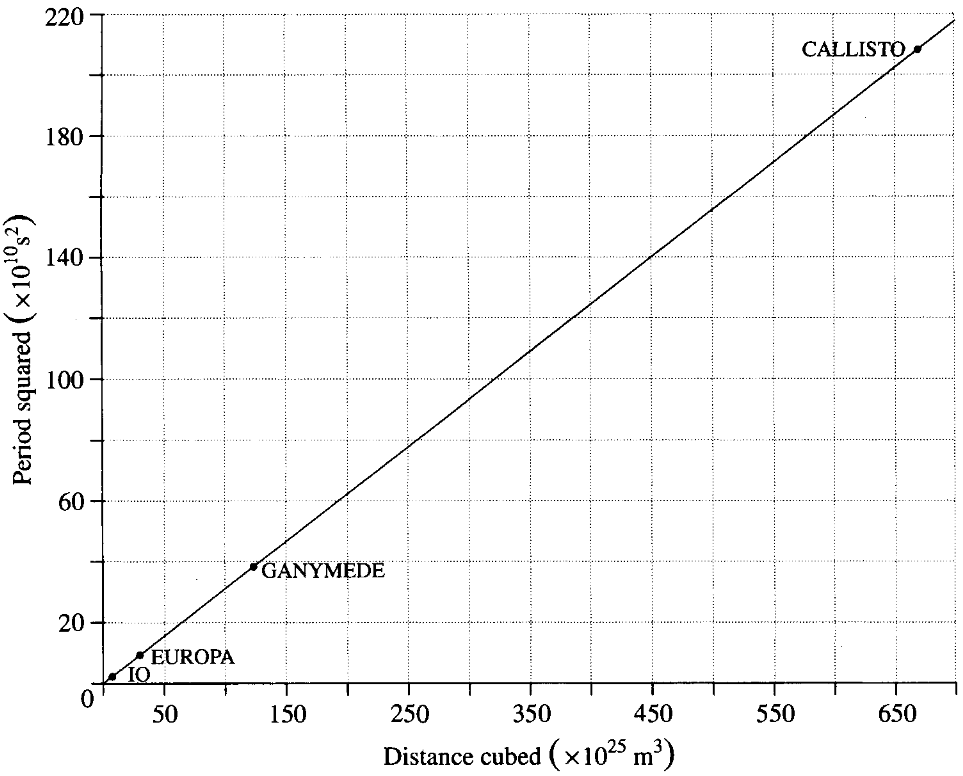
Marks

Question 22 (4 marks)

The graph below shows the relationship between the period and distance from the centre of Jupiter of four of its moons.



(a) Calculate the gradient of the graph. **2**

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(b) Hence, or otherwise, determine the mass of Jupiter. **2**

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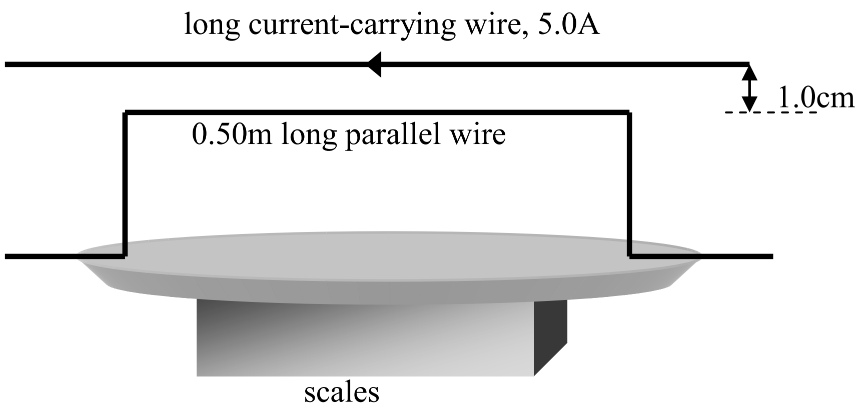
Marks

Question 23 (3 marks)

In an experiment to indirectly measure the current through a conductor, the following apparatus was constructed. **3**



The conductors are parallel for 0.500m, and are separated by 1.0cm. A current of 5.0A is flowing through the top conductor. When a current flows through the conductor which is resting on the scales, the scales measurement *increases* by 3.50×10^{-4}N.

Calculate the magnitude and direction of the current flowing through the conductor resting on the scales.

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Marks

Question 24 (3 marks)

Describe how the motor effect is used in the production of sound in loudspeakers. **3**

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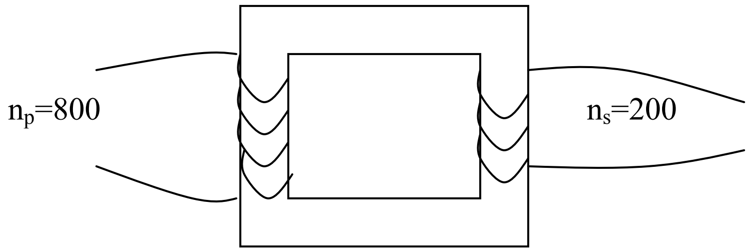
Question 25 (2 marks)

An ideal transformer (assume it is 100% efficient), is designed with a primary voltage of 2.0×10^5 V. Its input power is 20.0MW. **2**

A diagram of this ideal transformer is shown below.



Determine the secondary current in this ideal transformer.

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Marks

Question 26 (3 marks)

Eddy currents are used in a number of applications, including induction cooktops and electromagnetic braking. **3**

With reference to Lenz's Law, explain how eddy currents produced in a conducting disk can cause a braking effect.

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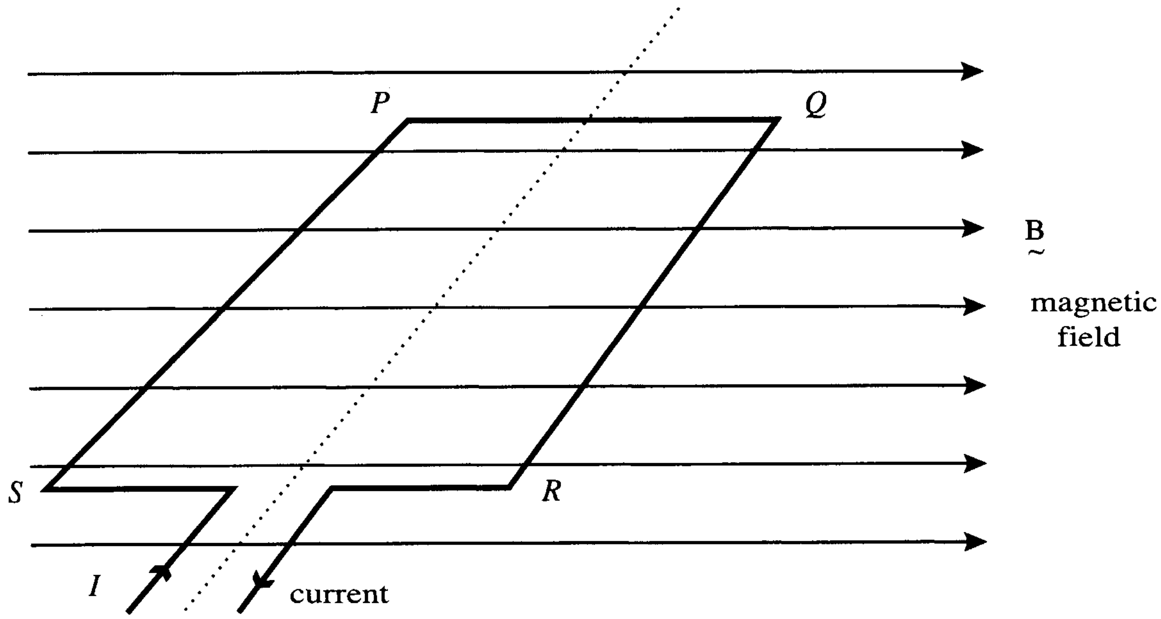
Marks

Question 27 (4 marks)

The diagram below shows a rectangular loop of wire placed parallel to a uniform magnetic field of strength 4.0×10^{-3} T. Side SP has length 5.0×10^{-2} m and side PQ has length 4.0×10^{-2} m.



When a current of 25 A flows through the loop it starts to rotate about the dotted line.

The rotation can be prevented by hanging a small mass at the centre of one of the longer sides of the loop.

(a) On which side should the mass be placed to prevent the rotation of the loop? **1**

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(b) Determine the minimum mass that would prevent the rotation of the loop. **3**

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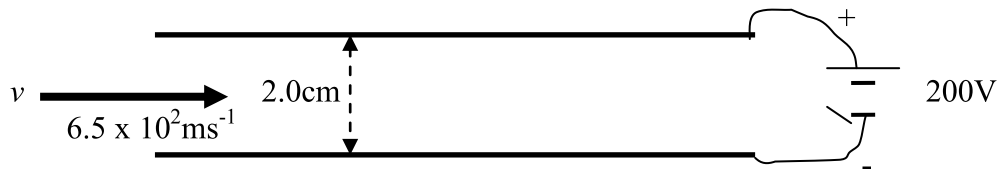
Marks

Question 28 (5 marks)

Cathode rays are directed into a region containing a uniform electric field, **E**, as shown below. They are moving with a speed of $6.5 \times 10^{2} ms^{-1}$.



(a) Calculate the magnitude of the electric field **E** between the two charged plates. **2**

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(b) Hence find the magnitude and direction of the magnetic field that must be produced between the two charged plates so that the cathode ray particles will pass through undeflected. **3**

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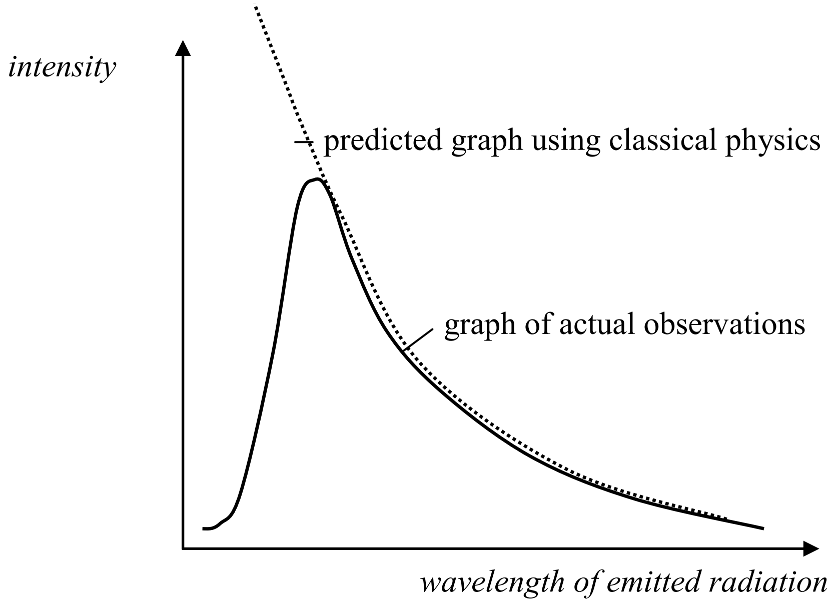
Marks

Question 29 (4 marks)

Einstein's explanation for the way in which energy is emitted from black bodies did not fit into the thinking of classical physics. **4**

Consider the graph of intensity versus wavelength of emitted radiation for a black body.



Describe how Einstein's contribution to quantum theory assisted physicists to overcome the shortcomings in the classical theory in relation to the above graph.

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Marks

Question 30 (2 marks)

Outline the first-hand investigation that you conducted to demonstrate the production and reception of radio waves. **2**

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Question 31 (8 marks)

Assess the impact on society and the environment of technologies that have been developed as a result of Faraday's discovery of electromagnetic induction. **8**

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Question 31 continues on page 20

Question 31 (continued)

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2007 HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Physics

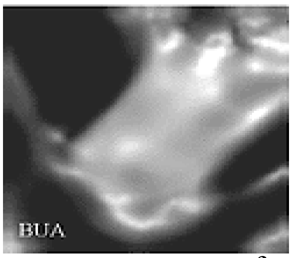
Section II

25 marks
Attempt Questions 32
Allow about 45 minutes for this section

Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Question 32 Medical Physics (25 marks)

(a) (i) The image below is that of a heel bone scan taken using ultrasound. **2**



source: www.cnrs.fr

Describe how this image could be used to determine bone density.

(ii) Identify the property of bone that makes it possible to obtain an ultrasound image while still surrounded by other tissue. **1**

(iii) Describe the differences between A scans and B scans and the particular situation in which each would be used. **3**

(b) (i) Explain the role of total internal reflection in the functioning of an endoscope. **2**

(ii) Discuss the use of different types of bundles of fibres in relation to their particular use in endoscopes. **4**

(c) Explain how the magnetic field produced by nuclear particles can be used as a diagnostic tool in medical applications. **7**

(d) (i) Radioactive isotopes are used to obtain scans of organs. Outline the properties of such radioactive isotopes that make them suitable for their intended purpose. **2**

(ii) Compare images produced by bone scan and by X-ray. **4**

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SCEGGS Physics Trial 2007 –Marking Guidelines

Question	1	2	3	4	5	6	7	8
Answer	C	A	C	C	D	B	D	A
Outcome	*H12*	*H6*	*H7*	*H6*	*H9*	*H9*	*H7*	*H9, H14*

Question	9	10	11	12	13	14	15
Answer	C	A	B	D	B	A	B
Outcome	*H3,H9*	*H9*	*H9, H14*	*H10*	*H8*	*H8, H10*	*H6, H9, H14*

Question 16 (a) (3 marks) **Outcomes assessed:** *H9, H14*

correctly uses equation with correct substitution to obtain correct value with direction	3
correctly uses equation with correct substitution to obtain correct value OR provides direction and correctly uses equation but makes error with substitution	2
correct equation selected with some values correctly substituted	1

Sample answer:

$$F = \frac{Gm_1m_2}{d^2}$$

$$= \frac{6.67\times10^{-11}\times6.0\times10^{24}\times200}{\left((6400+800)\times10^3\right)^2}$$

$$= 1543.98N$$

$\approx 1.5 \times 10^3$ N attraction

Question 16 (b) (2 marks) **Outcomes assessed:** *H6, H9, H14*

correctly uses equation with correct substitution to obtain correct value	2
correct equation selected with some values correctly substituted	1

Sample answer:

$$F_c = F_G \quad \Rightarrow \frac{mv^2}{r} = 1543.98 \quad \Rightarrow \quad \frac{200v^2}{\left((6400+800)\times10^3\right)} = 1543.98 \quad \Rightarrow \; v \approx 1.4 \times 10^3 \text{ ms}^{-1}$$

Question 17 (3 marks) **Outcomes assessed:** *H4, H6*

relates Earth's rotation (cause) to the increased launch velocity (effect) and hence reduced fuel needs and/or costs or masses involved (effect)	3
relates the cause to only one effect OR identifies two related effects but not the cause	2
identifies the cause or an effect	1

Sample answer:

A satellite launched from the Earth's surface gains a velocity in an easterly direction due to the rotation of Earth from west to east. The rotational velocity of the Earth is greatest at the equator because this part of the Earth covers the greatest distance (largest circumference) in 24 hours. Launching a satellite near the equator means that it has the rotational velocity of the Earth even before it is accelerated. This means that less fuel is required to achieve the same velocity for satellites launched closest to the equator. Fuel savings mean less mass and money are required.

Question 18 (4 marks) **Outcomes assessed:** *H1, H6, H13*

response includes the following points: • refers to Einstein and/or his special theory of relativity • states that the speed of light is constant regardless of the frame of reference • identifies the need for new standard in terms of the relativity of distance and time • relates new standard to its dependency on a value that is the same for all observers	3-4
response includes some of the above points	1-2

Sample answer:

Although inaccuracies arose from the copying of the metal rod (-), the need for a new standard resulted from our current understanding of relativity. Einstein's special theory of relativity identifies distance and time as relative, and so that at speeds approaching that of light, length measurements, such as the metre, become relative to the observer's frame of reference (-). A new standard was required that applied to any frame of reference was necessary because of time dilation and length contraction (-). The new standard uses the only constant that applies to all frames of reference, so that this standard is the same regardless of the frame of reference of the observer who is measuring it (+). (However, as can be seen by the degree of accuracy in the definition, sensitive technology is required for the current standard (-).)

Question 19a (1 mark) **Outcomes assessed:** *H6, H13*

correctly calculates the range in metres	1

Sample answer:

$\Delta x = u_x t = 52\cos 35^\circ \times 4.0 \approx 170$ m

Question 19b (3 marks) **Outcomes assessed:** *H6, H13, H14*

correctly uses vector addition to calculate speed in ms^{-1} and to 2 sig. figs	3
correctly determines horizontal and vertical components of motion	2
correctly determines horizontal or vertical components of motion	1

Sample answer:

$v_x = u_x = 52\cos 35^\circ \approx 42.5959...\ \text{ms}^{-1}$

$v_y = u_y + a_y t = 52\sin 35^\circ + (-9.8)\times 4.0 \approx -9.374...\ \text{ms}^{-1}$ up $\approx 9.374\ ...\ \text{ms}^{-1}$ down

$\therefore\ v = \sqrt{42.5959...^2 + 9.374...^2} \approx 44\ \text{ms}^{-1}$

Question 20 (2 marks) **Outcomes assessed:** *H1, H2, H14*

comprehensive answer using two separate light paths; reason for ether wind given	2
two separate light paths mentioned only	1

Sample answer:

The M-M experiment used interference of light, a very sensitive technique, to detect the speed of the Earth through the ether. It was assumed that light travelling back and against the ether should take longer than light travelling across the ether. However, the path difference demonstrated by the interference pattern was expected to change as the apparatus was rotated through 90° because the rays of light would have different resultant speeds due to their movement through the ether. By determining the speed of the ether wind, M-M would be providing evidence of its existence.

Question 21a (2 marks) **Outcomes assessed:** *H6, H13*

calculation/s made to compare both masses in kilograms	2
qualitative or generalised comparison made	1

Sample answer:

At rest, an electron's mass is 9.109 x 10^{-31}kg. Mass dilation increases the mass at v = 0.98*c* to:

$$m_v = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{9.109\times10^{-31}}{\sqrt{1-0.98^2}} \approx 4.6 \text{ x } 10^{-30} \text{ kg} >> 9.1 \text{ x } 10^{-31}\text{kg}$$

An electron moving at v = 0.98c is approximately 5 times more massive.

Question 21b (2 marks) **Outcomes assessed:** *H3, H5, H6*

mass dilation linked to increased energy required and energy of accelerated particle	2
relates mass dilation to one aspect of energy OR relates it to evidence for SR theory	1

Sample answer:

The energy of an accelerated particle is much greater than is given by the classical physics equation for kinetic energy, i.e. E_K=1/2mv^2. The dilated mass increases with speed, making them harder to accelerate but giving the particles more kinetic energy and hence ability to break apart other particles when they collide.

Question 22a (2 marks) **Outcomes assessed:** *H13, H14*

correctly calculates gradient in s^2m^{-3}	2
uses the graph to calculate a gradient	1

Sample answer:

$$m = \frac{rise}{run} = \frac{(140\times10^{10}-0)s^2}{(450\times10^{25}-0)m^3} \approx 3.1\times10^{-16} \text{ s}^2\text{m}^{-3}$$

Question 22b (2 marks) **Outcomes assessed:** *H6, H14*

correctly calculates mass using graph and Kepler's Law of Periods	2
identifies Kepler's Law of Periods as relevant to the calculation of mass	1

Sample answer:

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2} = \frac{1}{m} \Rightarrow \frac{6.67\times10^{-11}M}{4\pi^2} = \frac{1}{3.1\times10^{-16}} \Rightarrow M \approx 1.9 \text{ x } 10^{27} \text{ kg}$$

Question 23 (3 marks) **Outcomes assessed:** *H9, H13, H14*

substitutes correctly into equation to calculate the magnitude and direction of current	3
makes one error in substituting and calculating the magnitude and direction of current	2
identifies the correct equation or identifies correct direction of the current	1

Sample answer:

$$\frac{F}{l} = \frac{kI_1I_2}{d} \Rightarrow \frac{3.50\times10^{-4}}{0.500} = \frac{2.0\times10^{-7}\times5.0\times I_2}{1.0\times10^{-2}} \Rightarrow I_2 \approx 7.0A \text{ to the right}$$

Question 24 (3 marks) **Outcomes assessed:** *H7, H9, H14*

identifies the motor effect and clearly relates it to sound production in a loudspeaker	3
relates the principle of motor effect to motion in loudspeaker	2
identification of basic principle of motor effect	1

Sample answer:
A coil connected to an external power source is located in a radial magnetic field produced by circular permanent magnets in the loudspeaker. (A diagram would help here). A lightweight cone is connected to the coil. The external power source is varies according to the recording being played changing the direction and the strength of the current through the coil. The motor effect (the force acting on a current-carrying wire in a magnetic field) causes the coil to experience forces that cause it to move back and forth at various rates and distances. The cone attached to the coil vibrates generating longitudinal sound waves of various frequencies and volume.

Question 25 (2 marks) **Outcomes assessed:** *H7, H9, H14*

all steps of required calculations performed with correct substitutions throughout	2
correctly calculates the secondary voltage OR uses power equivalence for current	1

Sample answer:

$$\frac{V_P}{V_S} = \frac{n_P}{n_S} \Rightarrow \frac{2.0\times 10^5}{V_S} = \frac{800}{200} \Rightarrow V_S = 5.0\times 10^4 \text{ V}$$

$$P_{out} = P_{in} \text{ (100\% efficient) } \Rightarrow V_S I_S = P_{in} \Rightarrow 5.0\times 10^4 \times I_S = 20.0\times 10^6 \Rightarrow I_S = 4.0x10^2 \text{ A}$$

Question 26 (3 marks) **Outcomes assessed:** *H3, H9, H14*

all necessary steps are linked and Lenz's Law described correctly	3
most steps are correctly made and Lenz's Law is described in general	2
some steps are identified in the process	1

Sample answer:
Parts of the disk are subjected to a changing magnetic flux which induces an emf (Faraday's Law) and eddy currents in the sheet of metal of which the disk is made. As the disk rotates, parts of it enter a region of magnetic field produced by magnets either side of the disk. While the flux is changing (in the part of the disk approaching or receding from the magnetic field), eddy currents, or circular currents, flow in the disk in such a direction as to produce a magnetic field which opposes the change in the original flux (i.e. Lenz's Law). The eddy current's magnetic field opposes the external field, to reduce the relative motion and causes a braking effect.

Question 27a (1 mark) **Outcomes assessed:** *H9, H14*

identifies the correct side of the coil	1

Sample answer:
side QR (right hand side of coil)

Question 27b (3 marks) **Outcomes assessed:** *H6, H13, H14*

correctly equates gravitational and magnetic forces to determine the minimum mass	3
equates gravitational and magnetic forces but makes a minor error	2
calculates the magnetic force	1

Sample answer:

$$F_g = F_B \Rightarrow mg = nBIl\sin\theta \Rightarrow m \times 9.8 = 2\times(1\times 4.0\times 10^{-3}\times 25\times 5.0\times 10^{-2}\sin 90^0) \Rightarrow m \approx 1.0\times 10^{-3}\text{ kg}$$

Question 28a (2 mark) **Outcomes assessed:** *H9, H14*

correctly calculates electric field and provides appropriate units	2
substitutes into the correct equation	1

Sample answer:

$$E = \frac{V}{d} = \frac{200}{0.02} = 1.0\times 10^4\, Vm^{-1}$$

Question 28b (3 marks) **Outcomes assessed:** *H9, H14*

correctly equates electric and magnetic forces to find magnitude and direction of B	3
correctly equates electric and magnetic forces to find magnitude of B	2
provides correct direction of B OR equates forces to determine size of B ORcorrectly calculates the electric force	1

Sample answer:

$$F_E = F_B \Rightarrow Eq = qvB\sin\theta \Rightarrow v = \frac{E}{B} \Rightarrow 6.5\times 10^2 = \frac{1.0\times 10^4}{B} \Rightarrow B \approx 15\text{ T into the page}$$

Question 29 (4 marks) **Outcomes assessed:** *H1,H2, H7, H10, H14*

response includes the following points: • problems with predicted graph/shortcomings in classical theory (i.e. refers to the uv catastrophe and experimental results not matching predicted) • difference/s between Planck and Einstein's contributions to quantum theory (i.e. black body radiation solution and explanation of photoelectric effect respectively) • differences/s between classical and quantum theory	4
response includes some of the above points	2-3
identifies one point relevant to graph or quantum theory	1

Sample answer:

The graph predicted using classical physics had two problems. Firstly, it implied that the law of energy would be violated by hotter black bodies that emitted energy in the uv spectrum (i.e. the uv catastrophe). Secondly, the actual observation did not match the predicted graph. Planck was the first to propose the idea of discrete energy bundles (E=nhf) as a way of 'solving' the curve using statistics. He hypothesised that the energy emitted by the atoms if a black body was quantised. Einstein contributes dot quantum theory by extending Planck's idea of quantised energy when he explained observations of the photoelectric effect that also did not fit with classical theory. Rather than a mathematical trick related to the emission of energy from atoms, Einstein proposed that energy was absorbed or emitted in discrete quantities because it was a discrete quantity itself rather than the continuous quantity that was ascribed to it in the classical theory.

Question 30 (2 marks) **Outcomes assessed:** *H8, H10*

describes suitable method of production and reception of radio waves	2
describes suitable method of production and reception of radio waves OR reception of radio waves OR provides insufficient detail in method for their production and reception	1

Sample answer:

We connected an induction coil to a power pack and placed a radio tuned to an AM station nearby. When we switched on the power pack so that radio waves were produced by the induction coil, we heard static on the radio indicating that the radio waves were received.

Question 31 (8 marks) **Outcomes assessed:** *H3,H4, H9, H13, H14*

response includes the following points: • describes electromagnetic induction and a number of related technologies • describes many positive and negative impacts of some technologies on society • describes many positive and negative impacts of technologies on the environment • makes an overall judgement about the impact of the technologies AND response is concise and coherent	7-8
response includes most of the above points	5-6
response includes some of the above points	3-4
identifies one or two applications/technologies resulting from Faraday's discovery OR identifies one or two relevant societal and/or environmental impacts	1-2

Sample answer:

Several technologies have been developed as a result of Faraday's discovery of electromagnetic induction. These technologies include generators, transformers, induction motors, induction cooktops and electromagnetic braking. Of these, generators and transformers have changed our lives the most. They have enabled AC electricity to be transmitted relatively cheaply and efficiently across great distances enabling us to live further from power stations. This has had the impact of reducing the air pollution clusters in the cities but has led to clearing of trees for transmission lines. It has provided a convenient source of energy which in turn has led to its great use by society. Whilst there have been health and educational benefits of the electronic technologies that rely on electricity, the increased demand for electricity has associated negatives for the environment. Not only does increased supply mean more mining is necessary but more burning of coal has impacts on global warming. The negatives of greater use of electronic technologies are not limited to the environment. Many children spend endless hours on the computer and such time is believed to contribute to obesity. Less manual labour is also necessary when induction motors can do the difficult work for us. Whilst the technologies associated with electromagnetic induction can present employment possibilities, requirement for a more skilled labour market is the most likely outcome. Society has been made safer by the use of induction cooktops and electromagnetic braking. Apart from the improvement in the efficiency of induction cooktops, the fact that the stove top is not directly heated reduces the likelihood of children suffering unnecessary burns as they invariably explore their world. Electromagnetic braking relies on the interaction of a magnetic field and a sheet of metal rather than direct contact slowing the motion. This means that as long as the magnet is not damaged, the braking mechanism will continue to operate indefinitely unlike standard brakes that wear out because of the friction between the surfaces that causes the braking to occur. Whilst there are a number of negatives for the environment associated with the technologies that have been developed as a result of Faraday's discovery of electromagnetic induction, the alternatives to supplying society with energy in this way are probably worse due to their inefficiencies and polluting effects. In terms of society, the impacts of the technologies reliant on electromagnetic induction are more beneficial for people than the environment.

Question 32a (i) (2 marks) **Outcomes assessed:** *H8*

description of method outlined clearly and relates well to image provided	2
some identification of technique	1

Sample answer:

This heel bone scan shows the density of the bone by the way in which ultrasound is reflected from the bone. The denser the bone, the greater the reflection, and the more contrast in the image. Referenced against calibrated images provides a measure of bone density.

Question 32a (ii) (1 mark) **Outcomes assessed:** *H8*

identifies correct property	1

Sample answer: acoustic impedance (NOT simply "density")

Question 32a (iii) (3 marks) **Outcomes assessed:** *H3*

describes differences AND identifies a specific use of each type of scan	3
describes differences OR identifies a specific use for each type of scan	2
identifies one difference OR identifies one use	1

Sample answer:

A scans provide a simple one-dimensional graph, usually on a CRO screen, showing the relative intensities of reflections from boundaries in 1D. They are used for detailed measurements of the eye. B scans show relative intensities by brightness rather than the amplitude on a graph. A linear array is also usually used in B scans so that 2D images can be produced. 2D B scans are used for imaging the foetus and abdominal organs.

Question 32b (i) (2 marks) **Outcomes assessed:** *H8*

describes TIR and relates it to light travelling along fibres towards/away from organ/s	2
describes TIR OR relates it to light travelling along fibres towards/away from organ/s	1

Sample answer:

Total internal reflection (TIR) enables internal organs to be illuminated (via incoherent fibre bundles) and a focused image to be produced outside the body (via coherent fibre bundles). As long as the light entering the fibre bundles is above the critical angle, light will be reflected along the individual fibre with no loss of intensity even if the fibre bundles are bent.

Question 32b (ii) (4 marks) **Outcomes assessed:** *H3, H8*

response includes the following points: • identifies the properties of coherent and incoherent fibre bundles • distinguishes between the roles of coherent and incoherent fibre bundles • provides one point for using different types of fibre bundles (eg. specialisation) • provides one point against using different types of fibre bundles (eg. costs) AND response is concise and coherent	4
response includes most of the above points	3
distinguishes between the two types of bundles by name or function	2
describes one type of fibre bundle OR identifies the function of one fibre bundle type	1

Sample answer:

An incoherent bundle of optical fibres is used to transmit light from an external source to within the body to illuminate the area of interest. Coherent bundles of optical fibres are used to convey images from within the body, the exterior end connected to a camera a video. Unlike coherent fibre bundles in which the fibres are kept aligned within the bundle so that an image can be built up and is not scrambled, there is no need for the fibres in an incoherent bundle to keep the fibres aligned or to have the individual fibres as thin for better image resolution. A disadvantage of having different types of fibre bundles is that more fibres are required. However, using separate fibre bundles means that each bundle type is better suited for its role. Additionally, thinner fibres used in coherent bundles to improve resolution are not required in incoherent bundles. The lack of requirement for such thin fibres and no alignment makes incoherent bundles cheaper.

Question 32c (7 marks) **Outcomes assessed:** *H3, H7, H9, H14*

response includes the following points: • relates spin of nuclear particles to the magnetic field of a nucleus (ie. net spin) • refers to the function of the 5 main parts of MRI equipment • describes the effect of a strong magnetic field on nuclei with net spin • describes the processes of resonance and relaxation and how they arise • explain how a 2D image is formed and at least TWO applications of these images AND response is concise and coherent	7
response includes most of the above points	5-6
response includes some of the above points	3-4
identifies one or two aspects of MRI technique	1-2

Sample answer:

The nuclei of hydrogen-1 atoms have a net spin state of ½ because they consist on one unpaired proton. When nuclei with net spin are subjected to a strong magnetic field, they precess at what is known as their Larmor frequency (which depends on the strength of the B-field and their composition). They precess out of phase with slightly more aligned parallel than anti-parallel to the B-field. It is the difference in populations between these two states that determines the MRI signal strength. Radio frequency (RF) pulses of radio waves are then directed at the precessing nuclei. Resonance occurs for the H-nuclei as their Larmor frequency matches that of the RF pulse. This absorption of energy causes these H-nuclei to precess in phase and for some of them to flip to the higher energy state of alignment anti-parallel to the B-field. The signal given off when these H-nuclei relax, ie. return to how they were precessing before the RF pulse was applied, is detected by coils by the process of electromagnetic induction. The signal, known as the free induction decay signal (FID), is then sent to the computer to be interpreted. Three gradient coils are also applied to enable the computer to determine the location of individual signals. A B-field is applied along the body (z-axis) before the RF pulse so that only the H-nuclei in a slice of the body resonate. Immediately after the RF pulse, whilst the nuclei are precessing in their resonant state, two more fields are applied, to change the frequency in the x-axis and phase in the y-axis, to slightly alter the signal that will be detected from different parts of the slice. The computer uses Fourier transforms (ie. opposite of superposition) to determine the signals from the different parts of the slice and to enable an image to be formed. Tissues are differentiated from each other because of their proton density as well as the difference in relaxation rates of H-nuclei in different tissues and surroundings. MRI can be used to detect cancerous tissue, areas of high blood flow (using fMRI) and to distinguish between grey and white matter in the brain.

Question 32d (i) (2 marks) **Outcomes assessed:** *H3, H10*

describes several appropriate properties	2
describes one appropriate property	1

Sample answer:

Such radioisotopes are non-toxic, have relatively short half-lives (ie. not too long to endanger the patient but long enough to accumulate in required organ), emit only gamma radiation of an intensity that enables it to be detected outside the body. These radioisotopes may also accumulate in a particular organ or are able to be easily attached to a compound that will do so.

Question 32d (ii) (4 marks) **Outcomes assessed:** *H8, H10*

both types of image described with detail and compared thoroughly	4
both images described and comparison made	3
both image types described with limited detail	2
one type of image described	1

Sample answer:

A bone scan is produced when a radioisotope (usually Technetium-99) is injected into the subject. Areas of bone which take-up more of the radioisotope usually represent a tumour, fracture or infection, and show up when the gamma radiation is detected and an image produced. An X-ray image is produced when an X-ray source is placed behind the subject, and bone absorbs more of the X-rays than surrounding soft tissue. Fractures can be revealed, however infections or tumours may not be detected as readily as in bone scans. X-rays do not require any injection into the patient, whereas bone scans do. Images of bone scans show functional information (ie. hot and cold spots representing high/low activity) whereas X-rays only show structural information (eg. fractures) because they only show how the X-rays have been attenuated. Both types of scans use a grey scale and involve em radiation.