Mark schemes

1 (a) (i) primary coil with more turns than secondary coil **(1)**

(wound around) a core **or** input is ac **(1)**

2

(ii) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

QWC	descriptor	mark range
good-excellent	Two causes of energy losses are clearly identified, correct measures to indicate how these two losses may be reduced are stated and a detailed physical explanation of why these measures are effective is given. eg **any two** from the following four 1 When a transformer is in operation, there are ac currents in the primary and secondary coils. The coils have some resistance and the currents cause **heating of the coils**, causing some energy to be lost. This loss may be reduced by using **low resistance wire** for the coils. This is most important for the high current winding (the secondary coil of a step-down transformer). Thick copper wire is used for this winding, because thick wire of low resistivity has a low resistance. 2 The ac current in the primary coil magnetises, demagnetises and re-magnetises the core continuously in opposite directions. Energy is required both to **magnetise and to demagnetise the core** and this energy is wasted because it simply heats the core. The energy wasted may be reduced by choosing a material for the core which is easily magnetised and demagnetised, ie a **magnetically soft material** such as iron, or a special alloy, rather than steel. 3 The magnetic flux passing through the core is changing continuously. The metallic core is being cut by this flux and the continuous change of flux induces emfs in the core. In a continuous core these induced emfs cause currents known as **eddy currents**, which heat the core and cause energy to be wasted. The eddy current effect may be reduced by laminating the core instead of having a continuous solid core; the laminations are separated by very thin layers of insulator. Currents cannot flow in a conductor which is discontinuous (or which has a very high resistance). 4 If a transformer is to be efficient, as much as possible of the magnetic flux created by the primary current must pass through the secondary coil. This will not happen if these coils are widely separated from each other on the core. **Magnetic losses** may be reduced by adopting a design which has the two	**5-6**

	coils close together, eg by **better core design**, such as winding them on top of each other around the same part of a common core which also surrounds them.	

modest-adequate	Up to two sources of energy losses are stated and there is an indication of how these may be minimised by suitable features or materials. There is no clear appreciation of an understanding of the physical principles to explain why these measures are effective.	**3-4**
poor-limited	Up to two sources of energy losses are given, but the answer shows no clear understanding of the measures required to minimise them.	**1-2**
incorrect, inappropriate or no response	There is no answer or the answer presented is irrelevant or incorrect.	**0**

Answers which address only **one** acceptable energy loss should be marked using the same principles, but to max 3.

6

(b) (i) power wasted internally (= $I\ V$) = 0.30 × 9.0 = 2.7 (W) **(1)**

1

(ii) input power $\left(= \frac{2.7}{0.90}\right)$ = 3.0 (W) **(1)**

mains current $\left(= \frac{3.0}{230}\right)$ **(1)** (= 1.30×10^{-2} A)

2

(iii) energy wasted per year (= $P\ t$) = $3.0 \times 0.80 \times 3.15 \times 10^{7}$
= $7.5(6) \times 10^{7}$ (J) **(1)**

1

(iv) energy wasted = $\frac{7.56 \times 10^{7}}{3.6 \times 10^{6}}$ = 21.0 (kWh) **(1)**

cost of wasted energy = 21.0 × 20 = 420p (£4.20) **(1)**

2

(c) answers should refer to:

an advantage of switching off **(1)**

- cost saving, saving essential fuel resources, reduced global warming etc

a disadvantage of switching off **(1)**

- inconvenience of waiting, time taken for computer to reboot etc
- risk of computer failure increased by repeated switching on and off
- energy required to reboot may exceed energy saved by switching off

2

[16]

2 (a) (i) out of plane of diagram **(1)**

(ii) circular path **(1)**
in a horizontal plane [or out of the plane of the diagram] **(1)**

$BQv = \frac{mv^2}{r}$ **(1)**

radius of path, $r \left(\frac{mv}{BQ}\right) = \frac{1.05 \times 10^{-25} \times 7.8 \times 10^{5}}{0.28 \times 2 \times 1.6 \times 10^{-19}}$ **(1)**

= 0.91(4) m **(1)**

max 5

(b) (i) radius decreased **(1)**
halved **(1)**
[or radius is halved **(1) (1)**]

(ii) radius increased **(1)**
doubled **(1)**
[or radius is doubled **(1) (1)**]

max 3

[8]

3 (a)

quantity	SI unit	
(gravitational potential)	J kg^{-1} or N m kg^{-1}	scalar
(electric field strength)	N C^{-1} or V m^{-1}	vector
(magnetic flux density	T or Wb m^{-2} or N A^{-1} m^{-1}	vector

6 entries correct **(1) (1) (1)**
4 or 5 entries correct **(1) (1)**
2 or 3 entries correct **(1)**

3

(b) (i) $mg = EQ$ **(1)**

$E\left(\frac{mg}{Q} = \frac{4.3\times10^{-9}\times9.81}{3.2\times10^{-12}}\right)$ = 1.32 × 10^4 (V m^{-1}) **(1)**

(ii) positive **(1)**

3

[6]

4 (a) units: F - newton (N), B - tesla (T) or weber metre^{-2} (Wb m^{-2}),
I - ampere (A), l - metre (m) **(1)**
condition: I must be perpendicular to B **(1)**

2

(b) (i) mass of bar, $m = (25 \times 10^{-3})^2 \times 8900 \times l$ **(1)**
(= 5.56l) weight of bar (= mg) = 54.6l **(1)**
$mg = BIl$ or weight = magnetic force **(1)**
54.6l = B × 65 × l gives B = 0.840 T **(1)**

(ii) arrow in correct direction (at right angles to I, in plane of bar) **(1)**

5

[7]

5 (a) (i) uud **(1)**

(ii) $u\bar{d}$ **(1)**

2

(b) (i) $\frac{mv^2}{r} = Bev$ [or $r = \frac{mv}{Be}$] **(1)**

$m = 1.67 \times 10^{-27}$ **(1)**

$r\left(\frac{mv}{Be}\right) = \frac{1.67 \times 10^{-27} \times 1.5 \times 10^{7}}{0.16 \times 1.6 \times 10^{-19}}$ **(1)**

= 0.98 m **(1)**

(ii) pion path more curved than proton path **(1)**

(iii) path more curved
[or radius (of path) smaller] **(1)**
for both paths **(1)**

7

[9]

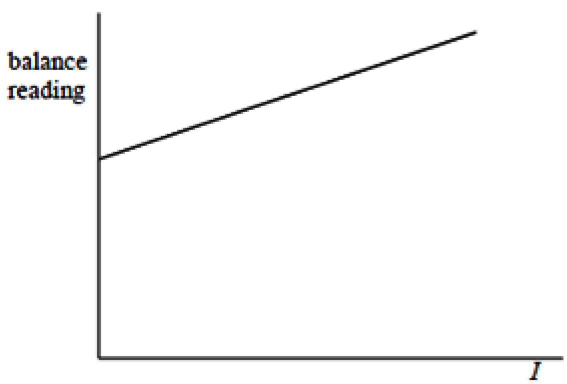
6 (a) (i) interaction between current and B-field gives force on wire **(1)**
equal and opposite force on magnet (down) **(1)**

(ii) force on wire must be up **(1)**
∴ current right to left **(1)**
by left hand rule **(1)**

(iii) (force = BIl = mg = change in mass × 9.8)
B × 5.0 × 0.060 = 1.54 × 10^{-3} × 9.8 **(1)**
B = 0.050 T [50.3 mT] **(1)**

(max 6)

(b)



straight line **(1)**
intercept, upward slope **(1)**

(2)

[8]

7 B

[1]

8 C

[1]

9 **A**

[1]

10 **D**

[1]

Examiner reports

1 In part (a) (i), the requirement that $N_p > N_s$ was regarded as fundamental for the first mark; the second mark was awarded for either a core linking the coils or an ac supply. Some candidates missed the point of the question completely by writing about how transformers change voltages rather than concentrating on their essential features.

Most attempts to answer part (a) (ii) fell well short of examiners' expectations. In many cases the principal cause of this was a lack of detailed knowledge or confused understanding. When this kind of question is employed to assess the quality of candidates' written communication, it will be expected that a good answer will be structured: well organised, and coherent. This was another general error, because candidates often presented answers that rambled on without general direction.

Successful answers were primarily expected to address **two** (and only two) causes of energy loss; four causes are commonly identified by the standard sources that deal with this topic, so asking for two was not unduly demanding. For each cause that was identified, there was a requirement to discuss how the loss could be reduced by suitable features and materials.

Answers that could be placed in the 'good to excellent' category (five or six marks) should have backed up this factual knowledge with some physical reasoning. Very few answers addressed these requirements sufficiently successfully to deserve the award of full marks. It seemed that most of the candidates had heard about eddy currents, but not all of them knew exactly what they are or where they occur. Many answers showed considerable confusion; 'eddy currents caused by the coils can be stopped by using a soft iron core', 'heat losses from the currents can be reduced by using smaller currents', and 'energy losses from re-magnetising the core can be cut down by laminating it' were typical of the confused responses seen.

A proportion of the candidates evidently mixed up the principles of energy loss reduction in transformers with the principles involved in reducing power losses from transmission cables, because there were frequent references to using higher voltages in the transformers in order to reduce the currents causing the heating.

The calculations in parts (b) (i) and (ii) were usually correct, with $P = I\ V$ and the transformer efficiency equation being successfully applied. Almost all of the answers to part (b) (iii) were incorrect, because candidates did not realise that when on standby the transformer, as well as the load, continues to waste energy. Consequently, the power wasted on standby was 3.0 W, not 2.7 W.

This error did not prevent candidates from accessing both available marks in part (b) (iv), provided they correctly applied the physical principles there. In this part, relatively few completely correct answers were seen, largely because the candidates were unable to convert an energy value from J to kWh.

In part (c) it was usual to award both marks; most candidates knew that it takes an appreciable time for a computer to boot up and this would therefore be a disadvantage of switching off. For the advantage, a more specific point than 'saves energy' was being looked for, because this response does little more than re-state the question.

2 Students are much more accustomed to diagrams which show magnetic fields acting at right angles to the plane of a diagram, than magnetic fields acting in the plane of a diagram. Consequently the seeds of confusion were sown at the start of part (a) for a large proportion of the candidates, many evidently treating the question as though it referred to an electric field. Therefore the path of the ion in part (ii) was stated to be parabolic, and not circular, in a large number of the scripts. Perhaps the aim of the required calculation was a little obscure, but a question about a circular path ought to have triggered 'radius' in the minds of the candidates. Many calculated this radius very successfully, the principal error being a wrong value for the charge of the doubly-charged ion.

In part (b) it was not possible to award any marks to candidates who were convinced that the path was parabolic; they tended to write about curves that were 'steeper' or 'with a bigger slope', etc.

3 Units of the various physical quantities related to fields and the scalar/vector nature of them, are generally not well known by the candidates. Part (a) showed that the 2004 cohort were no better than their predecessors. Six correct entries in the table were required for three marks, and it was very rare for all three to be awarded. The unit of N m kg^{-1} was accepted as an alternative to J kg^{-1} for gravitational potential, but candidates regularly put N kg^{-1} in the table. The unit of electric field strength was known better, and that of magnetic flux density was usually shown correctly. Candidates often resorted to guesswork when completing the second column of the table. Many did not appreciate that the concept of potential arises from energy considerations and that it is therefore a scalar quantity, whilst the other two quantities are force-related and therefore vectors.

Completely correct answers to part (b) were encountered in many of the scripts. Since the unit of E had already been tested in the table in part (a), no penalty was imposed for wrong or missing units in the answer to part (b)(i). A worrying error, made by a significant minority of the candidates, was to equate the electric force on the particle to its mass, rather than to its weight.

4 The lack of familiarity of candidates with the units of electromagnetic quantities continues to be a cause for concern. All four units had to be correct for the first mark in part (a). It might have been anticipated that candidates would make an incorrect choice for *B*, such as the regularly encountered Wb. The many candidates who could not identify the SI unit of force (sometimes N m^{-1} or J m^{-1} were given) came as a greater surprise. The most common error in the second aspect of part (a) was to state that the *force* must be perpendicular to the magnetic field, although some candidates confused the question with electromagnetic induction and thought that the conductor had to be moving.

A large number of clear and succinct solutions were seen in the answers to part (b), although many other candidates were stumped by the need to combine ideas about magnetic force and weight. Equating *mass* with magnetic force was regarded as a serious error of physics for which no further marks could be given. The final part of the question required the accurate application of Fleming's left-hand rule; this defeated far more candidates than it ought to have done.

5 The majority of candidates were able to give the correct quark composition of the proton in part (a), but many were unable to give the correct quark composition of the positive pion, usually as a result of stating that the antiquark was strange.

In part (b) the calculation of the radius of curvature was usually correct although some candidates did not use the correct mass value for the proton. In part (ii) the majority of candidates knew the pion path was more curved and were thus able to score full marks. In the final part candidates often failed to state that the radius of curvature would be less for both types of particles.

6 There were some very vague statements in answer to part (a). The majority of candidates said that a downward force was acting, either on the wire, pushing it down on to the balance, or by some other mysterious means producing an increase in the balance reading. A surprising number of candidates stated that the increase in mass was due to “the moving electrons”. Only a small proportion of those who said clearly that there was a force on a current-carrying conductor in a magnetic field went on to deduce that there would be an equal opposite force on the magnet and hence the balance. Thus only a few candidates gained all the marks in part (a)(ii) for the correct application of Fleming’s left hand rule to a wire experiencing an upward force in the field. One mark was awarded to those candidates who considered a downward force correctly, provided they gave their reasoning. The majority of candidates knew how to do the calculation, but some omitted to change kg to N, did not take the difference in the balance readings, made mistakes in arithmetic or gave the wrong unit. Similarly. The majority of candidates knew that the graph in part (b) was a straight line, but many forgot the intercept.

9 This question, concerning the magnitude and direction of the force acting on a current-carrying wire in a uniform magnetic field, was the easiest question (facility 88%). Evidently the application of $F = B I l$ together with Fleming’s left hand rule caused few problems.

10 This question required students to decide through what angle (in rad), and in which direction, a coil should be rotated in order to achieve maximum and minimum values of flux linkage. 66% of them were successful. Distractor A, which was almost the exact opposite of the correct answer, was the most popular incorrect response.