



NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY 2014

PHYSICAL SCIENCES: PAPER I

MARKING GUIDELINES

Time: 3 hours

200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1 MULTIPLE CHOICE

- 1.1 D (2)
 1.2 C (2)
 1.3 A (2)
 1.4 D (2)
 1.5 C (2)
 1.6 D (2)
 1.7 A (2)
 1.8 C (2)
 1.9 B (2)
 1.10 B (2)

[20]

QUESTION 2 WORLD'S HIGHEST ROLLER COASTER

2.1 $v_f = v_i + a\Delta t$
 $57,2 = 0 + 16,3\Delta t$
 $\Delta t = 3,51 \text{ s}$ (4)

2.2 $v_f^2 = v_i^2 + 2a\Delta x$ OR $\Delta x = \frac{(v_i + v_f)\Delta t}{2}$ OR $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$
 $57,2^2 = 0^2 + 2(16,3)\Delta x$ $\Delta x = \frac{(0 + 57,2) \cdot 3,51}{2}$ $\Delta x = 0(3,51) + \frac{1}{2}(16,3)3,51^2$
 $\Delta x = 100,36 \text{ m}$ $\Delta x = 100,41 \text{ m}$ (4)
 $\Delta x = 100,39 \text{ m}$

2.3 Work-energy theorem
 $W_{\text{net}} = \Delta E_k \text{ (metode)}$
 $= \frac{1}{2} \times 8500 \times 57,2^2$
 $W_{\text{net}} = 1,39 \times 10^7 \text{ J (13 905 320 J)}$

Newton's 2nd Law
 $F_{\text{net}} = ma$ $W_{\text{net}} = F_{\text{net}} \cdot \Delta x$
 $= 8500 \times 16,3$ $= 138550 \times 100,36 \text{ c.o.e.}$
 $F_{\text{net}} = 138 550 \text{ N}$ $W_{\text{net}} = 1,39 \times 10^7 \text{ J}$ (4)

2.4 **Greater** than
 In addition to doing work in order to accelerate the train the cable is also doing work to move the train against the frictional forces opposing its motion. (3)

2.5 $P = \frac{W}{t}$
 $= \frac{1,39 \times 10^7}{3,51} \text{ c.o.e. from 2.1 and 2.3}$
 $P = 3,96 \times 10^6 \text{ W}$

% efficiency = $\frac{3,96 \times 10^6}{1,5 \times 10^7} \times 100$
 $= 26,4\%$ (5)

2.6 2.6.1 Mechanical energy is kinetic energy **plus** gravitational potential energy.

$$\text{OR } E_{\text{mechanical}} = E_p + E_k \quad (2)$$

$$\begin{aligned} 2.6.2 \quad E_{\text{mech}} &= E_k + E_p \\ &= \left(\frac{1}{2} \times 8\,500 \times 8^2\right) + (8500 \times 10 \times 139) \\ &= 272\,000 + 11\,815\,000 \\ &= \mathbf{12\,087\,000\,J} \quad (1,21 \times 10^7 \text{ J}) \quad \text{OR } \mathbf{1,19 \times 10^7 \text{ J}} \text{ if } g = 9,8 \text{ m.s}^{-2} \end{aligned} \quad (5)$$

2.6.3 Work done against friction = $1,39 \times 10^7 - 1,21 \times 10^7$ c.o.e from 2.3 and 2.6.2

$$= \mathbf{1,8 \times 10^6 \text{ J}} \text{ of } \mathbf{2,0 \times 10^6 \text{ J}} \text{ as } g = 9,8 \text{ m.s}^{-2} \quad (3)$$

2.6.4 The train may not make it to the top of the tower (B)

If $E_K \text{ at A} < (E_P \text{ at B} + W_{\text{friction AB}})$.

OR If the amount of work done against friction is greater than 272 000 J (c.o.e. from 2.6.2 for E_K at B).

OR As the frictional force increases the work done against friction increases, and the kinetic energy of the train decreases. (3)

[33]

QUESTION 3 SAFETY ON THE KINGDA KA

3.1 3.1.1 The net force acting on a body is equal to the **rate of change of momentum** of the body. (2)

3.1.2 The elastic material stretches therefore **increasing the time** over which the momentum of the body changes. This **decreases the force** acting on the rider since $F_{\text{net}} = \Delta p/t$ ($F_{\text{net}} \propto 1/t$) therefore less chance of injury. (3)

3.1.3 The headrest prevents whiplash or a broken neck or serious neck injuries (at such extreme accelerations).

The high back rest exerts force on the head ensuring that the head accelerates with the rest of the body

OR

In the absence of any head support, the body would accelerate with the train whilst the head would remain stationary (in its original position or be "left behind") due to its inertia (its resistance to the sudden acceleration). (4)

3.2 3.2.1 The relative velocity of an object is the velocity as defined by a given observer OR it is the vector difference (or sum) in the velocities of the two objects. (2)

3.2.2 30 m.s^{-1} towards the boy (2)

3.2.3 $F_{\text{net}} = \frac{m\Delta v}{t}$
 $= \frac{0,08(-24 - 6)}{0,05}$ conversion
 $F_{\text{net}} = -48 \text{ N}$ (Accept 48 N as only magnitude required) (5)

3.2.4 The bird and the boy experienced the same size force (either stated or implied) A force of 48 N is large enough to kill the 80 g bird which underwent a sudden large change in speed and direction. The boy was part of the train system which has a mass in excess of 8 000 kg and therefore experiences a negligible change in speed and no change in direction. (4)

[22]

QUESTION 4 PROJECTILE MOTION

4.1 4.1.1 30 m.s^{-1} (1)

4.1.2 **Metho 1**

$$\begin{aligned}\text{Height} &= \text{area under graph (method)} \\ &= \left(\frac{1}{2} \times 3 \times -30\right) + \left(\frac{1}{2} \times 6 \times 60\right) \\ &= \mathbf{135 \text{ m}}\end{aligned}$$

Method 2

$$\begin{aligned}\Delta y &= \frac{(v_i + v_f)\Delta t}{2} \\ \Delta y &= \frac{(-30 + 60) \cdot 9}{2} \\ \Delta y &= \mathbf{135 \text{ m}}\end{aligned}$$

Method 3

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$60^2 = (-30)^2 + 2(10)\Delta x$$

$$\Delta x = 135 \text{ m}$$

$$(\text{If } g = 9,8 \text{ m.s}^{-2} \Delta x = 137,76 \text{ m})$$

Method 4

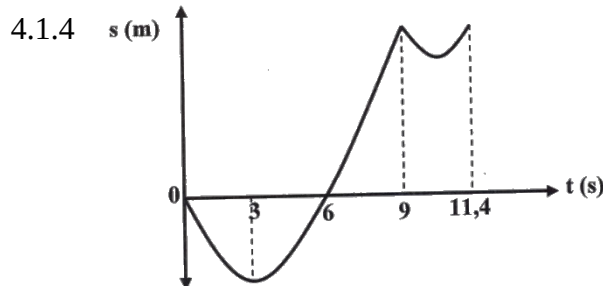
$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta x = -30(9) + \frac{1}{2} (10) 9^2$$

$$\Delta x = 135 \text{ m}$$

(4)

4.1.3 Once or (1x) of (1) or one bounce (2)



Marks

(times do not need to be shown)

0 – 3 s

3 – 6 s

6 – 9 s

9 – 11,4 s

If graph is inverted about x-axis
take off one mark

(4)

4.2 $v_x = 15 \cos 60 = 7,5 \text{ m.s}^{-1}$

$$\Delta t = \frac{\Delta x}{v_x}$$

$$\Delta t = \frac{12}{7,5}$$

$$\Delta t = 1,6 \text{ s}$$

$$v_y = 15 \sin 60 = 12,99 \text{ m.s}^{-1}$$

$$\Delta y = v_y \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta y = 12,99(1,6) + \frac{1}{2}(-10)(1,6)^2$$

$$\Delta y = \mathbf{7,98 \text{ m}}$$

John's ball does not pass through the hole.

OR

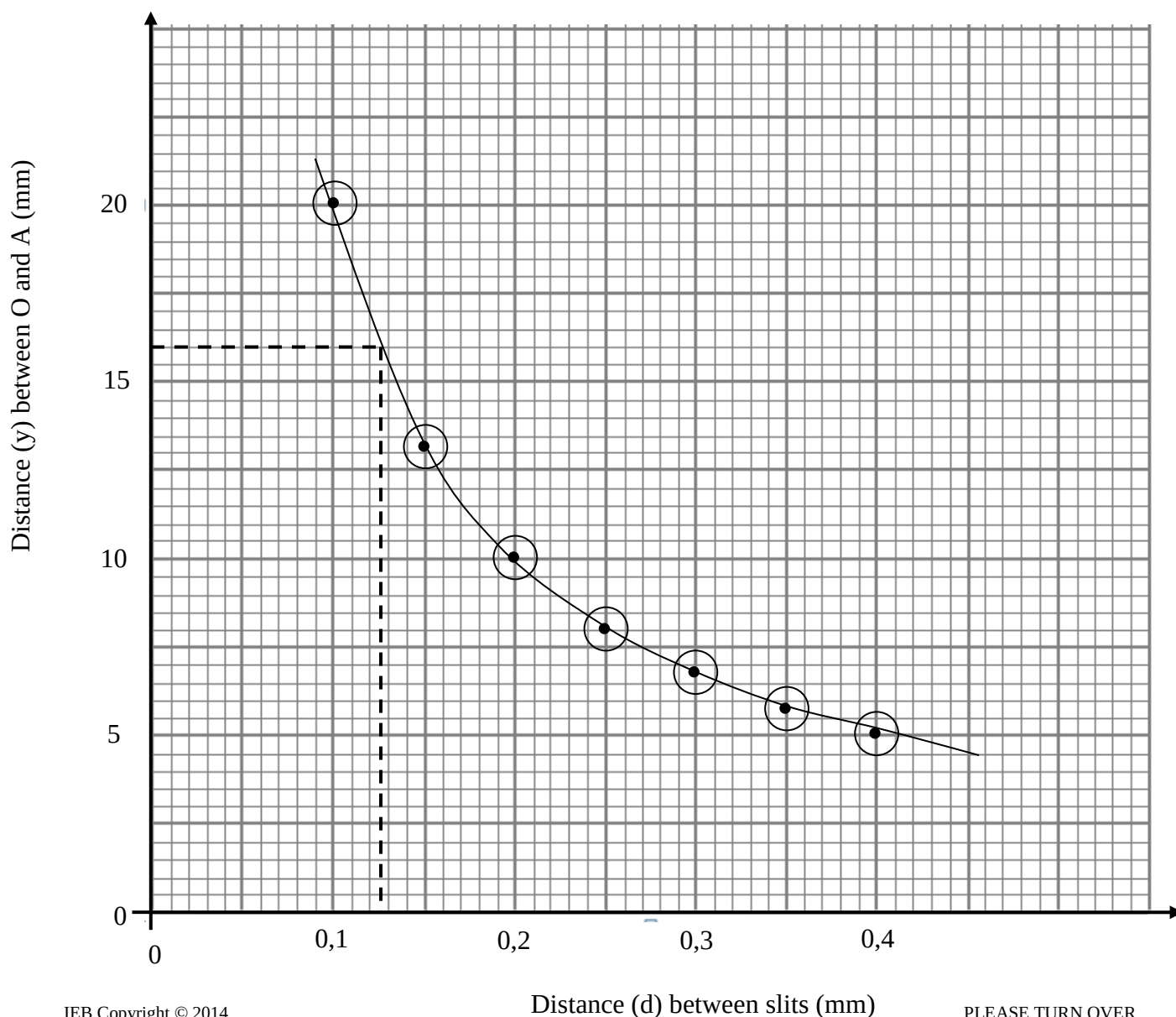
$$\Delta y = 8,49 \text{ m as } g = 9,8 \text{ m.s}^{-2}$$

(9)

[20]

QUESTION 5 INTERFERENCE OF LIGHT

- 5.1 Diffraction is the ability of a wave to spread as it passes through a small aperture or around a sharp edge in a shadow region. (2)
- 5.2 **Constructive** interference. The waves arrive at A **in phase**. (2)
- 5.3 **Dark band out of phase destructive** interference (3)
- 5.4 **Antinodal** line since it joins points where the waves meet **in phase/undergo constructive** interference (2)
- 5.5 5.5.1 Distance (d) between the slits (2)
- 5.5.2 If the distance between the screen and the slits was to change it would affect the dependent variable (distance (y) between O and A) and it would not be a fair test. (2)
- 5.5.3 Graph to show the relationship of the distance (y) between O and A and the distance (d) between the slits for the interference of light



Marking of graph

Heading

Both axes labelled with units

Correct scale on both axes

All points plotted correctly (Maximum of one mark if any errors)

Smooth curve through points (7)

5.5.4 $\pm 0,125 \text{ mm}$ (2)

5.5.5 The distance (y) between O and A is inversely proportional to the distance (d) between the slits. (2)

OR

As the distance (d) between the slits increases the distance (y) between O and A decreases. (2)

5.5.6 $y \cdot d = \text{constant}$
 $y \cdot d = 2$
 $y = 2 + 1.25$
 $y = \mathbf{1,6 \text{ mm}}$ (3)

5.5.7 $\frac{1}{d} \text{ units} = \text{mm}^{-1} \text{ or } \frac{1}{\text{mm}}$ (2)

[29]

QUESTION 6 ELECTRIC CIRCUIT

$$\begin{aligned}
 6.1 \quad I &= \frac{V}{R} \\
 I &= \frac{1,92}{6} \\
 \mathbf{I} &= \mathbf{0,32 \text{ A}} \quad (3)
 \end{aligned}$$

$$\begin{aligned}
 6.2 \quad V &= I R \\
 &= 0,4 \times 4,5 \\
 \mathbf{V} &= \mathbf{1,8 \text{ V}}
 \end{aligned}$$

$$\begin{aligned}
 R_T &= \frac{18 \times 6}{(18 + 6)} \quad \text{OR} \quad \frac{1}{R_T} = \frac{1}{18} + \frac{1}{6} \\
 &= 4,5 \, \Omega \\
 R_T &= 4,5 \, \Omega
 \end{aligned}$$

6.3 More energy is used moving the bigger current through the internal resistance of the battery; therefore more volts are lost.
(Lost $V = Ir$) (2)

$$\begin{aligned}
 6.4 \quad I_{18 \, \Omega} &= \frac{V}{R} \quad \text{OF} \quad \text{Ratio } 6 : 18 \\
 & \quad 1 : 3 \\
 & \quad I_{18 \, \Omega} = \frac{1}{4} \times 0,4 \text{ A} \\
 & \quad \mathbf{I_{18 \, \Omega} = 0,1 \text{ A}} \\
 I_{18 \, \Omega} &= \frac{1,8}{18} \quad \text{c.o.e. from 6.2} \\
 \mathbf{I_{18 \, \Omega} = 0,1 \text{ A}} \quad (4)
 \end{aligned}$$

$$\begin{aligned}
 6.5 \quad W &= I^2 R t \\
 &= 0,1^2 \times 18 \times 300 \quad \text{c.o.e. from 6.3} \\
 &= \mathbf{54 \text{ J}}
 \end{aligned}$$

OR

$$\begin{aligned}
 W &= V I t \\
 &= 1,8 \times 0,1 \times 300 \quad \text{c.o.e. from 6.3} \\
 &= \mathbf{54 \text{ J}}
 \end{aligned}$$

OR

$$\begin{aligned}
 W &= \frac{V^2}{R} \cdot t \\
 &= \frac{1,8^2}{18} \cdot 300 \quad \text{c.o.e. from 6.2} \\
 &= \mathbf{54 \text{ J}} \quad (4)
 \end{aligned}$$

6.6 $\text{emf} = I(R + r)$
 $\text{emf} = 0,32 (6 + r)$ (i) c.o.e. from 6.1
 $\text{emf} = 0,4 (4,5 + r)$ (ii) c.o.e. from 6.2
 $0,32 (6 + r) = 0,4 (4,5 + r)$ (i) = (ii)
 $r = 1,5 \Omega$
 $\text{emf} = 2,4 \text{ V}$

OR

$\text{emf} = V_t + Ir$
 $\text{emf} = 1,92 + 0,32 r$ (i) c.o.e. from 6.1
 $\text{emf} = 1,8 + 0,4 r$ (ii) c.o.e. from 6.2
 $0 = 0,12 - 0,08 r$ (i) – (ii)
 $r = 1,5 \Omega$
 $\text{emf} = 2,4 \text{ V}$

(7)

- 6.7 Provided they conduct their experiment in the same manner with correct control of any fixed variables **they should obtain the same result** since the **internal resistance and the emf of a battery are fixed properties of the battery** and should not vary depending on the method used to find them.

(3)

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QUESTION 7 MOTOR AND GENERATOR

7.1 7.1.1 Negative. (2)

7.1.2 electrical energy to mechanical (kinetic) energy (2)

7.1.3 cars, fans, pumps ... (any 2 correct) (2)

7.1.4 (a) vertical
(b) horizontal (2)

7.1.5

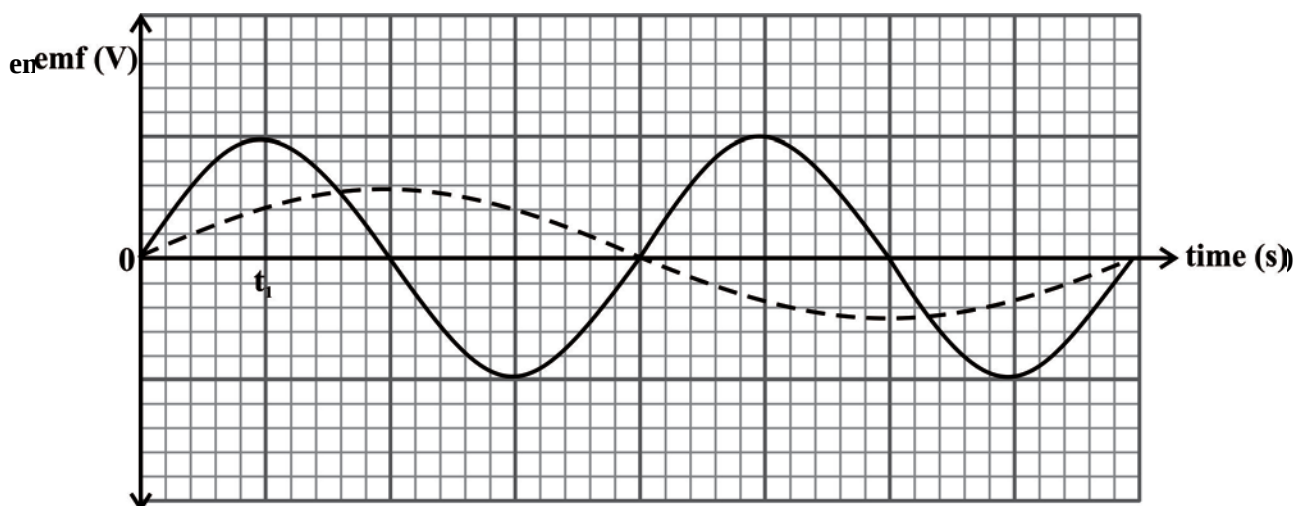
- When the coil is vertical the **gaps in the split ring commutator are opposite the brushes** therefore there is **no current** though the coil and hence no torque.
- When the coil is horizontal the **current direction is perpendicular to the magnetic field** which results in maximum torque. (4)

7.2 7.2.1 The DC motor has a split-ring commutator and the AC generator has slip rings
The DC motor has a power source and the AC generator has no power source (OR AC generator has source of mechanical energy/is rotated mechanically) (4)

7.2.2 The magnitude of the induced emf is directly proportional to the rate of change of magnetic flux linkage. (2)

7.2.3 Stronger magnets
More windings on the coil
Turn the coil faster (TWO only) (2)

7.2.4 (a) vertical (1)
(b) horizontal (1)
(c) • Half amplitude OR smaller amplitude
• Double the period OR longer period (4)



- 7.2.5 (a) No greenhouse gas emissions (less global warming)
NOT using up non-renewable fossil fuel (2)
- (b) Disposal of nuclear waste –remains radioactive for thousands of years – can
contaminate groundwater, soil, etc. if it leaks
Risk of meltdown/explosion/earthquake – massive exposure to radiation (2)
- [30]**

QUESTION 8 ELECTROMAGNETIC SPECTRUM AND PHOTOELECTRIC EFFECT

8.1 8.1.1 cell phone communication; cooking food (microwave ovens); radar speed traps ... (one use) (1)

$$\begin{aligned} 8.1.2 \quad \lambda &= \frac{v}{f} \\ &= \frac{3 \times 10^8}{6 \times 10^{15}} \\ &= 5 \times 10^{-8} \text{ m} \end{aligned} \quad (3)$$

8.1.3 X-rays (1)

8.2 8.2.1 The photoelectric effect is the emission of electrons from a metal by light (electromagnetic radiation) incident on the metal. (2)

$$8.2.2 \quad (a) \quad 2,9 \text{ eV} = 2,9 \times 1,6 \times 10^{-19} \\ = 4,64 \times 10^{-19} \text{ J} \quad (1)$$

$$(b) \quad E = hf_0 = W_f \quad \text{OR} \quad hf_0 = W_f + \frac{1}{2} mv^2$$

$$f_0 = \frac{4,64 \times 10^{-19}}{6,6 \times 10^{-34}} \text{ substitutions (c.o.e. from (a))}$$

$$f_0 = 7,03 \times 10^{14} \text{ Hz} \quad (4)$$

(c) Light shining on the metal is composed of photons, each of which possesses energy related to its frequency ($E = hf$).

If the energy possessed by the photons is greater than the work function of the metal, electrons can be released.

The photon must strike an electron which absorbs the entire amount of energy and is then released from the metal because it has sufficient energy to overcome the work function of the metal. (One to one correspondence of photons and electrons)

OR

An electron needs to gain a certain amount of energy (the work function) before it can escape from the metal. Each photon of light transfers its energy to one electron.

If the frequency of the photon is too low (below the threshold frequency)

then the energy of the photon is lower than the work function, since $E = hf$, therefore no electrons will be emitted. (3)

(d) (Using $E = W_f + \frac{1}{2} mv^2$ and $E = hf$)

$hf = W_f + E_K$ Using a suitable formula

$$E_K = (6,6 \times 10^{-34}) \times (6,0 \times 10^{15}) - 4,64 \times 10^{-19} \quad \text{c.o.e. from (a)}$$

$$E_K = 3,5 \times 10^{-18} \text{ J} \quad (4)$$

[19]

Total: 200 marks