NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER PAPER 2012

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	B	(2)
1.3	A	(2)
1.4	C	(2)
1.5	C	(2)
1.6	A	(2)
1.7	D (ALL Afrikaans candidates marked correct – error in question translation.)	(2)
1.8	B	(2)
1.9	C	(2)
1.10	B	(2)
		[20]

QUESTION 2 – 7: Where candidates use equivalent wording to that given in the marking guidelines, their answers must be marked correct.

QUESTION 2 TUGELA FALLS

2.1 Gravitational potential energy is the energy possessed by a body due to its position above the Earth's surface. (or relative to a reference point). (2)

2.2 $E_p = mgh$
$E_p = 6 \times 10^4 \times 10 \times 948$
$\mathbf{E_p = 5,69 \times 10^8\ J}$
ANS (using 9,8) : $5,57 \times 10^8$J (3)

2.3 2.3.1 kinetic energy to electrical (potential) energy (mechanical energy to electrical (potential) energy) (2)

2.3.2 $P = \frac{W}{t} = \frac{\Delta E_p}{t}$

$P = \frac{5,69 \times 10^8}{60}$ conversion

$= 9,48 \times 10^6$ W

Output = 80% of $9,48 \times 10^6$ = $\mathbf{7,58 \times 10^6\ W}$ (7,58 MW)

P = Fv = 6 x 10^4 x 15,8 = 9,48 x 10^6 W

OR

$E_p in = 5,69 \times 10^8$ J

E electrical out $= \frac{80}{100} \times 5,69 \times 10^8$ (method)

$= 4,55 \times 10^8$ J

$P = \frac{W}{t}$

Power out $= \frac{4,55 \times 10^8}{60}$

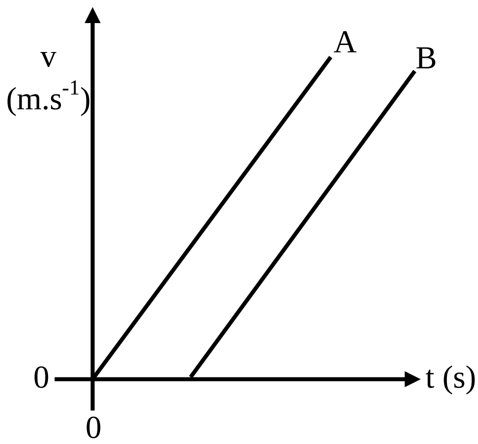
$= 7,58 \times 10^6$ W (5)

2.4 2.4.1 top of the waterfall (1)

2.4.2 Distance = 81 – 45 = **36 m**
(Reasonable accuracy of ± 1 m) (3)

2.4.3 Increasing (1)

2.4.4



One line correct
Second line parallel to first
(-1 if axes not labelled) (2)

2.4.5 10 m.s^{-1} down (or 9,8 m.s^{-1} down) (2)

2.5 2.5.1 **Vertical component of velocity**
v_y = vsinθ = 8sin50 = **6,13 m.s^{-1}** (method)
$v_f{}^2 = v_i{}^2 + 2a\Delta x$
0 = 6,13^2 + 2(–10) Δx (substitution signs for v_i and a must differ)
Δx = 1,88 m (above top of falls)
Max $\frac{2}{5}$ for not using vertical component of velocity)
ANS (using 9,8) : 1,92 m

OR $E_{k\ bottom} = E_{p\ top}$
½ m (8sin50)^2 = m(10)h
h = **1,88 m** (5)

2.5.2 **Time up**
$v_f = v_i + a\Delta t$
0 = -6,13 + 10Δt (signs)
Δt = 0,613 s (up)
c.o.e. from 2.5.1
ANS (using 9,8) : 0,6255 s

Time down
$\Delta x = v_i\Delta t + ½ a\Delta t^2$
(948 + 1,88) = 0 + ½ (10) Δt^2
Δt = 13,9 s (down) [14,04s]
Total time = 0,613 + 13,783
= 14,4 s (method)
ANS (using 9,8) : 14,5 s

Alternative: Time up and down
$\Delta x = v_i\Delta t + ½ a\Delta t^2$
948 = -6,13Δt + ½ (10)Δt^2 c.o.e. from 2.5.1
Δt = 14,4 s
Maximum $\frac{3}{5}$ for not using vertical component of velocity.
ANS (using 9,8) : 14,5 s (5)

OR $v^2 = u^2 = 2as$
= 6,13^2 + 2(-10)(-948)
= -137,83 m.s^{-1}

$t = \frac{(v - u)}{a} = \frac{-137,83 - 6,13}{-10}$ = **14,4 s**
BOTH formulae correct

2.5.3 **Horizontal component of velocity**

$v_y = v\cos\theta = 8\cos 50 = \mathbf{5{,}14\ m.s^{-1}}$

$\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ (a = 0) **OR** $\Delta x =$ average velocity $\times$ Δt

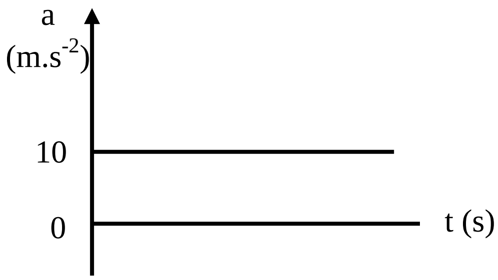
$\Delta x = 5{,}14 \times 14{,}4$ **OR** $\Delta x = \dfrac{v_i + v_f}{2}.\Delta t$

$\mathbf{\Delta x = 74\ m}$ c.o.e. from 2.5.2

Maximum $\dfrac{2}{4}$ for not using horizontal component of velocity.

ANS (using 9,8 $m{\cdot}s^{-2}$ in Question 2.5.2) : 74,52 m (4)

2.5.4



Line **above** time axis (positive)
(–1 if axes not labelled)

(If line is below time axis (negative))

(Accept 9,8 for acceleration) (2)

[37]

QUESTION 3 TOP-FUEL DRAGSTER

3.1 acceleration (1)

3.2 gradient (a) $= \dfrac{94 - 24}{2 - 0{,}5}$

$\mathbf{= 46{,}67\ \ m.s^{-2}}$
(accuracy)

- Allow calculation using any **TWO** points from the graph within the region of constant acceleration, e.g. (0 ; 0) and (1,75 ; 82)
- Allow $\pm$ 2 $m{\cdot}s^{-1}$ (1 block) different when reading from graph.

(4)

3.3 3.3.1 (uniform/constant acceleration) **OR** (uniformly/constantly increasing velocity) (forwards) (2)

3.3.2 (decreasing acceleration) **OR** (non-uniform acceleration) (forwards) (velocity increasing at a slower rate) (2)

3.4 Distance = area under graph
$= \frac{1}{2} \times 2 \times 94$
= 94,0 m (4)

Alternative solutions

$\Delta x = \dfrac{v_i + v_f}{2}.\Delta t$ **OR** $\Delta x = v_i\Delta t + \frac{1}{2} a\Delta t^2$ **OR** $v_f^2 = v_i^2 + 2a\Delta x$

$= \dfrac{(0 + 94)}{2}.2$ $\qquad = + \frac{1}{2}(46{,}7)\, 2^2$ $\qquad 94^2 = 0^2 + 2\,(46{,}7)\,\Delta x$ c.o.e 3.3

$\mathbf{= 94{,}0 m}$ $\qquad \mathbf{= 93{,}4\ m}$ $\qquad \mathbf{\Delta x = 94{,}6\ m}$

3.5 3.5.1 136 $m.s^{-1}$ (1)

3.5.2 $136 \times 3{,}6 = 489{,}6\ km.h^{-1}$ (c.o.e. from Question 3.5.1) (1)

3.6 **Solution** (using Newton's Second Law)

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

$0 = 145^2 + 2a(150)$

$a = -70{,}083\ m.s^{-2}$

$F_{net} = ma$

$= 1\ 000 \times -70{,}083$

$\mathbf{= -70\ 083\ N}$

Magnitude of net force = 70 083 N (7,01 × 10^4 N) (6)

Alternative solution (using Work-Energy Theorem)

$\Delta E_k = ½\ mv_f^2 - ½\ mv_i^2$

$= [\ ½ \times 1\ 000 \times 0^2] - ½ \times 1\ 000 \times 145^2$

$= (-)\ 10\ 512\ 500\ J\ \ 1{,}05 \times 10^7\ J$

$\Delta E_k = W = F_{net}\ \Delta x$ OR $\Delta E_k = F_{net}\Delta x.\cos\theta$

$10\ 512\ 500 = F_{net}\ (150)$

$\mathbf{F_{net} = 70\ 083\ N\ \ (7{,}01 \times 10^4\ N)}$

Alternative solution (using Impulse)

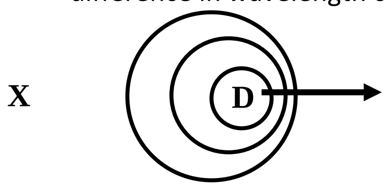
$\Delta x = \frac{(v_i + v_f)}{2}.\Delta t$ $\quad F_{net} = \frac{m(v-u)}{\Delta t}$

$150 = \frac{(145 + 0)}{2}.\Delta t$ $\quad = \frac{1\ 000(0 - 145)}{2{,}069}$

$\Delta t = 2{,}069\ s$ $\quad \mathbf{= -70\ 082\ N}$

3.7 **Diagram**
(maximum of 3 marks)
- Shape of wavefronts correct
- Relative difference in wavelengths correct
- X and D labelled in correct places

- Allow semi-circles
- Allow sinusoidal waves if difference in wavelength clear



Sound heard by observer at X
(2 marks)
- Deeper note (lower pitch) due to
- apparent decrease in frequency ()

OR Less waves reach observer per second. ()

OR Longer wavelength ()

() ONE of these points only

(5)

3.8 3.8.1 **Any TWO of the following:**
- It emits vast quantities of greenhouse gases (therefore contributing to climate change)
- After one race (of only 4 s) the whole engine has to be replaced. This is a waste of valuable resources.
- It is responsible for noise pollution.
- It consumes 23 litres of fuel in under 4 s – this fuel would need to be produced using energy consuming processes. (Waste of energy)
- In addition to greenhouse gases other poisonous gases would be emitted in the exhaust fumes causing air pollution.
- Fire hazard

(2 × 2 = 4)

3.8.2 It is very dangerous …
- Detached retinas
- Death
- Deafness/ear pain
- Fire hazard

Justification
Any of these reasons one mark

(2)

3.8.3 A shock wave is a (cone shaped) (high pressure) wave produced when the speed of the source is greater than or equal to the speed of the wave. (2)

3.8.4 It is NOT possible for the engine noise to cause a shock wave as the dragster is travelling at (480/3,6) = 133 $m.s^{-1}$ which is slower than the speed of sound. (3)
(OR speed of sound is 340 × 3,6 = 1 224 $km.h^{-1}$ which is faster than dragster)
(NOTE: The rapidly expanding gases from the combustion of the fuel can cause a shock wave.)

[37]

QUESTION 4 CAR CRASH

4.1 The (hardness/type of material of the) crash surface/barrier (barrier only gets 1) (2)

4.2 **Any TWO of the following ...**
Mass of car; speed of car; momentum of car; mass of barrier; angle of attack (barrier)
(Allow 'car') (2 × 2 = 4)

4.3 Impulse is the product of the **net** force acting on a body and the time for which it acts. (Product of net force and time gets one mark only)
OR
Impulse is the (instantaneous) change in momentum. (Instantaneous not essential) (2)

4.4 **Neither** are correct since the **change in momentum is the same** with both barriers.

Impulse = F.Δt = area under graph
Impulse for metal barrier = (½ × 0,04 × 12,6) = **0,252 $kg.m.s^{-1}$**
Impulse for foam rubber barrier = (½ × 0,12 × 4,2) = **0,252 $kg.m.s^{-1}$** (6)

4.5 Plastic foam bumpers **increase the time** over which the momentum changes, therefore **decreasing the (net) force** acting on the car, i.e. $F_{net} \propto 1/\Delta t$.
Smaller net force results in less damage to car. (3)
OR Steel barrier has greater (max/average) force therefore more damage.

4.6 $F_{net} = \dfrac{m(v - u)}{\Delta t}$ (backwards = negative direction)

$\Delta t = \dfrac{1\,200\ (-8 - 20)}{-\ 2{,}1 \times 10^5}$

= 0,16 s (5)

Alternative
$F_{net} = ma$ Both formulae correct
$-2{,}1 \times 10^5 = 1\,200 \times a$
$a = -175\ m.s^{-2}$

$v_f = v_i + a\Delta t$
$-8 = 20 - 175\Delta t$
$\Delta t = 0{,}16$ s

4.7 4.7.1 Work (done by a force) is defined as the product of the displacement and the component of the force in the direction of the displacement.
Work is the amount of energy transferred by the force. (2)
Force times displacement (1) OR product of force and displacement (1)

4.7.2 $W = F\Delta x\cos\theta$
$= 1\,500 \times 180 \times \cos 30$
$\mathbf{= 233\,826\ J\ or\ 2{,}34 \times 10^5\ J}$ (4)

4.7.3 Power is the rate of doing work OR Work done per unit time
OR
Power is the rate at which energy is expended. (2)

4.7.4 $P = F.v$ $F = 1500\cos 30 = 1\,299\ N$
$= 1\,299 \times 15$
$\mathbf{= 19\,485\ W\ or\ 1{,}95 \times 10^4\ W}$ (4)

Alternative
$\Delta x = v_i\Delta t + ½\, a\Delta t^2\ (a = 0)$
$180 = 15\Delta t$
$\Delta t = 12\ s$

$$P = \frac{W}{\Delta t}$$
$$= \frac{233\,826}{12}$$
$$\mathbf{= 19\,486\ W\ or\ 1{,}95 \times 10^4\ W}$$

4.7.5 (a) Equal to. (1)
(b) There has been no change to the component of the **applied** force in the direction of the displacement and there has been no change to the distance over which it has acted therefore
$W = F\Delta x\cos\theta$ has not changed.
NOTE: The net force acting on the car has changed which will affect the change in kinetic energy of the car but NOT the total work done. (3)

OR (a) less than
(b) Frictional forces have increased therefore loss in E_k
OR F_{net} opposite direction to motion therefore W_{net} decreases

[38]

QUESTION 5 WATER WAVES

5.1 A wavefront is an imaginary line that connects points on a wave that are in phase. (2)

5.2 5.2.1 No. of waves arriving at A from X = $\frac{11,7}{1,8} = 6,5$ (half number of waves)

No. of waves arriving at A from Y = $\frac{14,4}{1,8} = 8,0$ (whole number of waves)

Therefore waves will arrive at A **out of phase (crest meets trough)** and will undergo **destructive** interference. (3)

OR

Path difference between waves arriving at A from X and waves arriving at A from Y

= (14,4 – 11,7) = 2,7 m

No. of waves = $= \frac{2,7}{1,8} = 1,5$

Since the path difference corresponds to a **half number of waves (1,5 waves)** then they will arrive at A **out of phase** and will experience **destructive** interference.

5.2.2 No. of waves arriving at B from X = $\frac{9,0}{1,8} = 5,0$ (whole number of waves)

No. of waves arriving at B from Y = $\frac{7,2}{1,8} = 4,0$ (whole number of waves)

Therefore waves will arrive at B **in phase (trough meets trough or crest meets crest)** and will undergo **constructive** interference. (3)

OR

Path difference between waves arriving at B from X and waves arriving at B from Y

= (9,0 – 7,2) = 1,8 m

No. of waves = $\frac{1,8}{1,8} = 1,0$

Since the path difference corresponds to a **whole number of waves (1,0 wave)** then they will arrive at B **in phase** and will experience **constructive** interference.

5.3 B (c.o.e. must agree with Question 5.2) (2)

[10]

QUESTION 6 ELECTRIC CIRCUIT

6.1 Light emitting diode or An LED is a diode that emits light when it is forward biased. (2)

6.2 $R_T = \frac{V}{I}$

$R_T = \frac{9}{0,2}$ conversion

$\mathbf{R_T = 45\ \Omega}$ (4)

6.3 $\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2}$ $R_{eff} = \frac{R_1 \times R_2}{R_1 + R_2}$

$\frac{1}{R_{eff}} = \frac{1}{270} + \frac{1}{30}$ $R_{eff} = \frac{(270 \times 30)}{(270 + 30)}$

$\mathbf{R_{eff} = 27\ \Omega}$ $\mathbf{R_{eff} = 27\ \Omega}$ (3)

6.4 $R_X = (45 - 27)$

$\mathbf{R_X = 18\ \Omega}$ (2)

6.5 $P = I^2R$

$= 0,2^2 \times 18$

$\mathbf{P = 0,72\ W}$

Alternatives

$V = IR$	$P = VI$	**OR** $P = \frac{V^2}{R}$
$= 0,2 \times 18$	$= 3,6 \times 0,2$	$= \frac{3,6^2}{18}$
$= 3,6\ V$	$\mathbf{P = 0,72\ W}$	$\mathbf{P = 0,72\ W}$

(4)

6.6 Ratio 30:270

1 : 9

$I_Y = 1/10$ of 0,2 A

$\mathbf{I_Y = 0,02\ A}$

Alternative

$V = IR_{eff}$

$= 0,2 \times 27$

$= 5,4\ V$

$I = \frac{V}{R}$

$= \frac{5,4}{270}$

$\mathbf{I_Y = 0,02\ A}$ (4)

6.7 It protects the LED by using up the 'extra volts' so that the LED does not get more than 3 V as it would be damaged. (By limiting current through it so that the voltage across it is less than 3V.) (3)

6.8 6.8.1 Decrease (1)

6.8.2 Dimmer (1)

6.9 The LED is now in **reverse bias** therefore **no current** flows through this branch.
The **total resistance** of the circuit now **increases** (as one of the branches has been removed).
The current through the ammeter decreases as shown by the formula, **I = V/R** (V is constant therefore if R increases then I must decrease, I α 1/R).
The bulb gets dimmer as shown by the formula $\mathbf{P = I^2R}$ (R of bulb is constant therefore as I decreases P will decrease, P α I^2) (5)

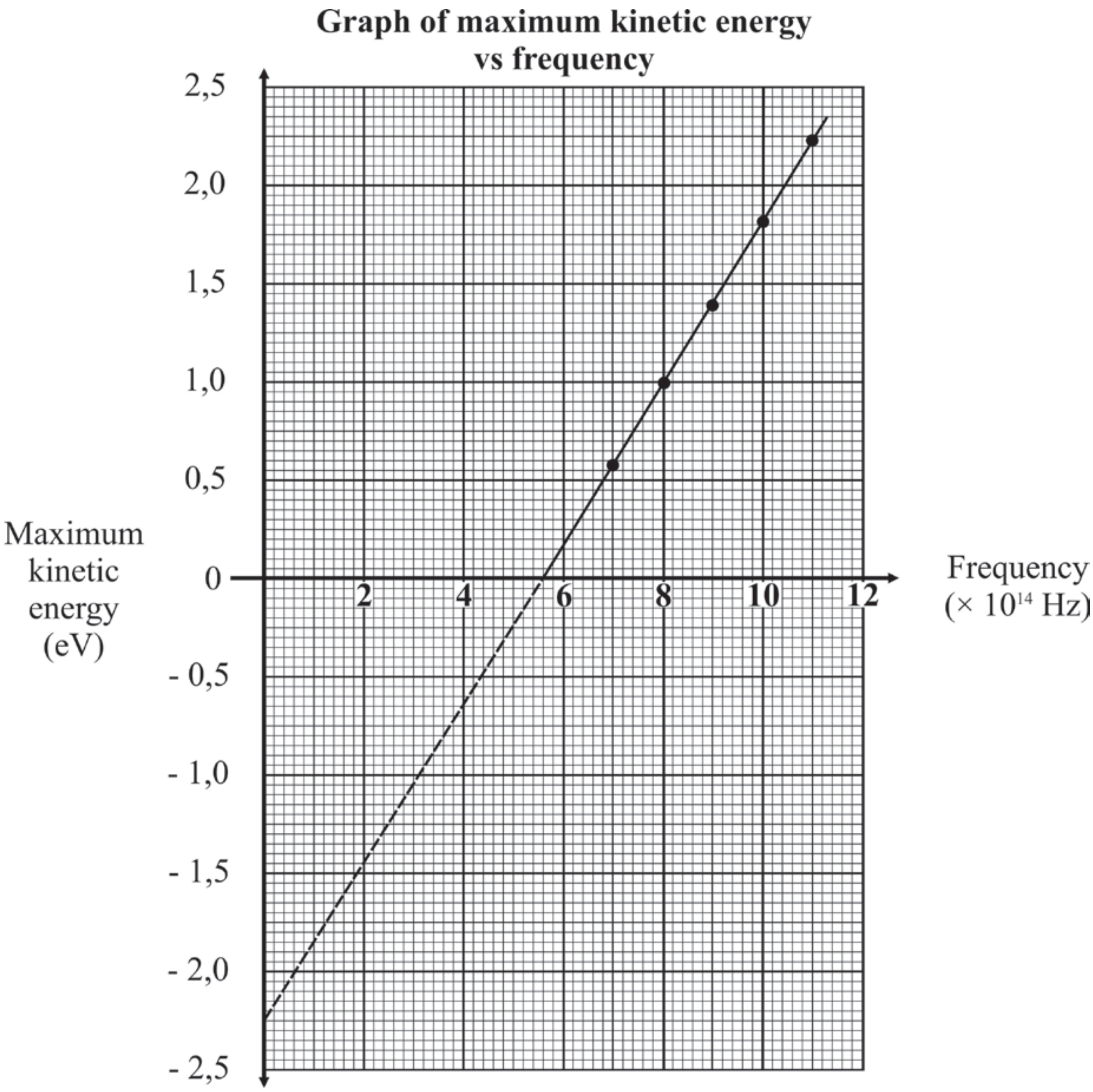
6.10 **Any TWO of the following**

- Brighter
- Use less energy/voltage/current/power … batteries last longer
- Less fragile
- More energy efficient therefore less wasteful of energy resources
- The LEDs last longer therefore less likely to end up on landfill sites
- Cheaper
- Switching time faster
- Do not release heat (2 × 2 = 4)

[33]

QUESTION 7 PHOTOELECTRIC EFFECT EXPERIMENT

7.1



Marking of graph

- x-axis labelled with units
- x-axis correct scale
- Points correct
- Straight line
- Heading
  (Extrapolation not needed at this stage) (6)

7.2 Threshold frequency is the minimum frequency of light (electromagnetic radiation) at which electrons will be emitted from a particular metal. (2)

7.3 $\pm$ 5,6 × 10^{14} Hz (2)

7.4 7.4.1 $\pm$ 10,4 × 10^{14} Hz (1)

7.4.2 $\lambda = \frac{c}{f}$

$= \frac{3 \times 10^8}{10,4 \times 10^{14}}$ c.o.e. from 7.4.1

$= \mathbf{2,88 \times 10^{-7}\ m}$ (288 nm) (3)

7.4.3 E = hf

= 6,6 × 10^{-34} × 10,4 × 10^{14} c.o.e. from 7.4.1

= 6,86 × 10^{-19} J (2,41 eV)

Alternative

$E = \frac{hc}{\lambda}$

$= \frac{6,6 \times 10^{-34} \times 3 \times 10^8}{2,88 \times 10^{-7}}$

= 6,86 × 10^{-19} J (2,41 eV) (3)

7.5 There would be NO CHANGE to the graph. Increasing the intensity would only increase the number of electrons emitted OR it would have no effect on the maximum kinetic energy of the electrons as each photon would still have the same amount of energy(E = hf). (ONE photon transfers its energy to ONE electron.)
NOTE: $E_k = hf - W_f$ therefore since hf and W_f have not changed then neither will E_k (3)
OR Energy of photon only depends on frequency
OR Increasing intensity does not affect frequency

7.6 7.6.1 W_f = 2,25 eV (see graph) (allow negative) (1)
7.6.2 W_f = 2,25 × 1,6 × 10^{-19} = **3,60 × 10^{-19} J** (1)

7.6.3 The graph cuts the y-axis when the frequency is zero.
If the frequency is zero then the energy (E) is zero since E = hf
If the energy is zero then …
$E = W_f + ½ mv^2$
$0 = W_f + ½ mv^2$
$-W_f = ½ mv^2$
As shown the magnitude of the work function is equal to the kinetic energy (½ mv^2) of the electrons when the frequency is zero, which is the y-intercept.

Alternative
Photoelectric effect equation, $E = W_f + ½ mv^2$ where E = hf and $E_k = ½mv^2$
Therefore $hf = W_f + E_k$
y-axis = E_k and x-axis = f
Equation of a straight line, y = mx + c
Rearranging photoelectric effect equation gives, $E_k = hf - W_f$
Therefore when frequency (x-axis) = 0 $E_k = -W_f$ (y-intercept)
OR
$-W_f$ corresponds to c (the y-intercept) (3)

[25]

Total: 200 marks