1. Motion, forces and energy

1.7 Energy, work and power

Paper 3 and 4

Answer Key

Paper 3

Q1.

(b)(i)	(work done =) 2000 (J)	**A3**
	(work done =) 40 × 50	(C2)
	(work done =) force × distance (moved in direction of force) OR (W) = $F \times d$	(C1)
(b)(ii)	internal OR thermal energy (of surroundings / tyres)	**B1**
	kinetic energy	**B1**

Q2.

Question	Answer	Marks
(a)(i)	(wasted output energy =) 12 (J)	**B1**
(a)(ii)	(form of energy wasted is) internal OR thermal (energy)	**B1**
(b)	(energy =) 4500 (J)	**A4**
	(energy =) 15 × 300	(C3)
	power = energy ÷ time OR (energy =) power × time	(C1)
	5.0 minutes = 300 s	(C1)
(c)	any **three** from: • infrared OR e-m waves (from Sun) heat atmosphere • thermal energy transfers to kinetic energy of wind • kinetic energy of wind transfers to KE of turbine / blades • KE of turbine transfers to KE of generator • generator transfers kinetic energy to electrical energy	**B3**

Q3.

(b)	11 000	**A3**
	14 000 × 0.78	(C2)
	(work =) force × distance OR (W =) $F \times d$	(C1)
	J	**B1**

Q4.

Question	Answer	Marks
(a)(i)	doesn't get depleted / continuously replenished / does not run out owtte	**B1**
(a)(ii)	(energy stored in) biofuels / tides / water waves / wind / geothermal / the Sun / solar	**B1**
(b)(i)	65	**B1**
(b)(ii)	35	**B1**
(c)	any **two** from: • depends on rainfall /drought • needs deep valleys / high hills owtte • relocation of community • disrupts habitats • disrupts community downstream	**B2**

Q5.

Question	Answer	Marks
(a)	any **two** from: • (they) (contribute to) global warming • (they) (contribute to) atmospheric / air pollution • (they are) non-renewable (energy source) • idea of energy security (for the country)	**B2**
(b)(i)	any **three** from: • water is stored behind a dam / in reservoir / lake • water (behind dam) has gravitational **OR** potential energy • water flows down / moves in / goes through pipe **OR** through (HEP) station **OR** through turbine • water turns / moves / rotates / spins turbine • (turbine) turns / moves / rotates / spins generator	**B3**
(b)(ii)	any **two** from: • (large area of) land flooded • relocation of population • damage to (land / valley) habitats **OR** migration of fish (upriver) interrupted owtte • vulnerable to drought • idea of limited suitable sites • reduced water supply downstream owtte	**B2**
(c)	any **one** from: • (energy stored) in battery • idea of pumping water / raising weight to higher level	**B1**

Q6.

Question	Answer	Mark
(a)(i)	light	B1
	sound	B1
(a)(ii)	(100 – 30 =) 70 (J)	B1
(b)(i)	any **three** from: • water (behind dam) has gravitational **OR** potential energy • water flows down / moves in / goes through pipe **OR** through (HEP) station **OR** through turbine • water turns / moves / rotates / spins turbine • (turbine) turns / moves / rotates / spins generator	B3

Question	Answer	Mark
(b)(ii)	any **one** advantage from: • renewable form of energy • no greenhouse gases **OR** no CO_2 • no atmospheric / air pollution • short start-up time owtte	B1
	any **one** disadvantage from: • (large area of) land flooded • relocation of population • damage to (land / valley) habitats **OR** migration of fish (upriver) interrupted owtte • vulnerable to drought • idea of limited suitable sites • reduced water supply downstream owtte	B1

Q7.

Question	Answer	Marks
(a)	KE of wind	B1
	rotates / turns / spins turbine OR blades	B1
	(turbine) turns / spins / rotates generator	B1
(b)	(output voltage =) 1200 (V) OR 1.2 kV	A4
	(V =) 624 000 ÷ 520	(C3)
	conversion: 624 kW = 624 000 (W)	(C1)
	power = $I \times V$ **OR** (V =) $P \div I$	(C1)
(c)	any **two** from: greater efficiency as lower current (is used) (so) reduces power / energy losses thinner cables can be used (so reducing costs) OR pylons further apart idea of increased distance of transmission (of electrical power)	B2

Q8.

Question	Answer	Marks
(a)	energy cannot be created or destroyed OR energy is only transformed or transferred (from one store / form / type to another)	**B1**
(b)(i)	30 (%)	**A2**
	100 – 70	(C1)
(b)(ii)	electrical car	**M0**
	greater kinetic energy (output) OR less energy wasted owtte	**A1**

Q9.

Question	Answer	Marks
(a)	31 (N)	**A2**
	(weight =) mass × gravitation field strength **OR** $m \times g$ **OR** $m \times 9.8$ OR 3.2×9.8	(C1)
(b)(i)	141(.12) (J) OR 139(.5) (J)	**B1**
	$3.2 \times 9.8 \times 4.5$ OR 31.36×4.5 OR 31×4.5	**B1**
	(work =) force × distance **OR** (W =) $F \times d$	**B1**
(b)(ii)	141(.12) (J) OR 139(.5) (J) OR 140 (J)	**B1**
	work done = gain in (g)PE	**B1**

Q10.

Question	Answer	Marks
(a)	any **two** from: no sulfur dioxide (emission) OR acid rain (produced) no CO_2 / greenhouse gases (emitted) OR no / reduces (impact on) global warming renewable (source of energy) no fuel predictable source owtte conserves coal / fossil fuel reserves	**B2**
(b)	any **two** from: suitable locations limited OR locations remote marine ecosystems disrupted difficult to maintain limited production time owtte silt build up electrical transmission difficult disrupts shipping storm damage	**B2**

Q11.

Question	Answer	Marks
(a)	C (energy from the Sun heats the atmosphere unevenly) D A F (moving air turns the turbine blades) B (the turbine blades turn a generator) E (the generator produces electrical energy) 4 correct – 3 marks 3 or 2 correct – 2 marks 1 correct – 1 mark	**B3**
(b)	any **two** from: • idea of large(r) area of land needed • intermittent supply **OR** cannot work if wind too strong / weak • idea that energy output is small / not very large • (possible) harm to (migrating) birds • difficult to maintain (particularly if off-shore) • noise **OR** visual pollution	**B2**

Q12.

Question	Answer	Marks
(a)(i)	50 (J)	**A3**
	(work done =) 25 × 2.0	(C2)
	(work done =) force × distance (moved in the direction of the force)	(C1)
(a)(ii)	same as answer to (a)(i) **OR** 50 (J)	**B1**
(a)(iii)	(some input energy is transferred as) thermal energy	**B1**
	to surroundings / motor	**B1**
(b)	(power output =) 16 (W)	**A3**
	(power output =) 80 ÷ 5(.0)	(C2)
	(power output =) energy output ÷ time	(C1)

Q13.

Question	Answer	Marks
(a)	chemical (energy)	**B1**
	light (energy)	**B1**
	30 (J)	**B1**
(b)	6.8 (J)	**A3**
	(work done =) 8.5 × 0.8(0)	(C2)
	(work done =) force × distance (moved)	(C1)

Q14.

Question	Answer		Marks
(a)	(useful energy transfers:)	kinetic (energy)	B1
	in either order	gravitational potential (energy)	B1
	(wasted energy transfer:)	thermal (energy)	B1

Q15.

Question	Answer	Marks
(a)	any **three** from: (moving) air has kinetic energy OR wind has kinetic energy (moving) air / wind turns turbine/blades turbine turns generator (rotating) <u>generator</u> produces/generates electricity	B3
(b)	any **two** from: (wind is) renewable (energy source) no greenhouse gases / CO_2 produced (during operation) no SO_2 OR acidic gases produced (during operation) OR no nitrous oxides produced	B2
(c)	any **two** from: large(r) area of land needed OR dilute energy source intermittent/inconsistent/unreliable supply OR cannot work if wind too strong/weak (possible) harm to (migrating) birds difficult to maintain (particularly if off-shore)	B2

Q16.

Question	Answer	Marks
(a)(i)	(X is a) turbine	B1
	(Y is a) generator	B1
(a)(ii)	any **two** from: chemical energy (in coal) to thermal/internal energy (in boiler) thermal/internal energy (of steam/water) to kinetic energy (of steam) kinetic energy of steam to kinetic energy of turbine/generator kinetic energy (of generator) to electrical energy	B2
(b)	200000 (V)	A3
	Vs / 25000 = 4800/600 OR Vs = (4800/600) × 25000 OR Vs = 25000 × 8 OR 4800/600 = ? / 25 000	(C2)
	Vs/Vp = Ns/Np in any form	(C1)

Question	Answer	Marks
(c)	any **two** from: reduces current (in cables) less energy or power wasted or less heating or more efficient enables use of thinner cables (so) lower cost for cable and supporting pylons transmit (electricity over) longer distances (without drop in p.d.)	B2

Q17.

Question	Answe	Marks
(a)(i)	hot / molten rocks	B1
(a)(ii)	kinetic (to)	B1
	electrical	B1
(b)(i)	Any **two** from: no sulphur dioxide OR acid rain produced no carbon dioxide / greenhouse gases produced OR no (contribution to) global warming no need to transport coal renewable (energy source) no fuel costs	B2
(b)(ii)	locations limited / land instability / distribution costs high / water pollution / smaller energy output / rocks may cool (over time)	B1

Q18.

Question	Answer	Marks
(a)	any **four** from: (coal/it is) burnt/burned (thermal energy from coal used to) heat/boil water steam (produced) turns/spins/moves turbine (which) turns/spins/moves generator	**B4**
(b)	idea that only a small proportion/fraction of the input energy is usefully transferred OR most of the input energy is wasted	**B1**

Question	Answer	Marks
(c)	any **two** from: releases sulphur dioxide/nitrogen oxide(s) OR produces acid rain releases CO_2/greenhouse gases OR (contributes to) global warming idea of need to transport coal idea of environmental impact of mining non-renewable fuel water pollution	**B2**

Q19.

Question	Answer	Marks
	Box 1 ✓	**B3**
	Box 2 ✓	
	Box 3	
	Box 4	
	Box 5 ✓	

Q20.

Question	Answer	Marks
(a)	gas AND oil both circled	**B1**
(b)	water is heated / **changed to steam** as it passes through (fractures in) rocks	**B1**
	steam turns a turbine	**B1**
	the turbine drives a generator	**B1**
	generator produces electricity	**B1**

Q21.

Question	Answer	Marks
(a)(i)	It will be used up / cannot be replaced (easily) owtte	**B1**
(a)(ii)	nuclear AND oil	**B1**
(b)	**Advantages– any two from** easy to store less atmospheric pollution than other fossil fuels cheaper than other fossil fuels concentrated energy source large reserves can respond to demand reliable **Disadvantages – any two from** (produces / releases) carbon dioxide (waste gases produce) acid rain (waste gases produced) contribute to global warming non-renewable danger of explosion danger of carbon monoxide poisoning long pipelines needed (from some gas fields)	**B4**

Q22.

Question	Answer	Marks
(a)	(gravitational) potential energy	**B1**
(b)	**Any 3 from:** water flows through tunnel / has kinetic energy when tide coming in / going out (moving) water causes turbines / (component) X to rotate / turn (the turbine)turns a generator	**B3**

Paper 4

Q23.

Question	Answer	Marks
(a)	*any **two** from:* • fossil fuels / named fossil fuel • biofuels / named biofuel / biomass • wave(s) • wind (turbines) • Hydroelectric • solar panels / solar cells	**B2**
(b)(i)	$E_k = ½ mv^2$	**B1**
	$(m =)\ 11000 \times 2 \div [6.3]^2$ **OR** $(m =)\ 11000 \times 2 \div [39.69]$ **OR** 554 (kg) SEEN	**B1**
(b)(ii)	55 (%)	**A2**
	efficiency = useful energy out(put) / (total) energy in(put) × 100 % OR $(6000 \div 11000) \times 100$	C1
(c)	(tides) follow a regular / predictable pattern **OR** (tides) are reliable ORA for wind	**B1**

Q24.

Question	Answer	Marks
(a)(i)	0.16 m / s	**A3**
	conservation of momentum **OR** $m_P v_P = m_Q v_Q$ **OR** $2.7 \times v_P = 1.2 \times 0.36$ **OR** $(m_Q v_Q =)$ 0.432 seen	C1
	$(v_P =)\ m_Q v_Q / m_P$ **OR** $1.2 \times 0.36 / 2.7$	C1
(a)(ii)	0.078 J	**A3**
	(k.e. =) $½mv^2$ **OR** (k.e. =) $½ \times 1.2 \times 0.36^2$	C1
	(k.e. =) $½ \times 1.2 \times 0.36^2$	C1
(b)	(from) elastic (energy store in the compressed spring)	**B1**
	to kinetic (as final energy store of trolleys)	**B1**

Q25.

Question	Answer	Marks
(a)	gravitational (potential) energy (store before / as the ball falls)	**B1**
	kinetic energy (store) increases (as the ball falls) **OR** energy transferred to kinetic energy (store as the ball falls)	**B1**
	(energy transferred from) kinetic energy (store) to internal / thermal energy (store)	**B1**
(b)	5.9 m / s	**A3**
	$(\Delta)E_p = (\Delta)E_k$ **OR** E_p lost = E_k gained **OR** gravitational potential energy lost = kinetic energy gained **OR** $mg(\Delta)h = ½mv^2$	C1
	$v^2 = 2g(\Delta)h$ **OR** $v^2 = 2 \times 9.8 \times 1.8$ **OR** $v^2 = 35(.28)$	C1

Q26.

Question	Answer	Marks
(a)	20 J	**A2**
	$(\Delta.E_p =) mg(\Delta)h$ **OR** $0.2(0) \times 9.8 \times 10$	C1
(b)(i)	14 J	**A2**
	$(E_k =) ½mv^2$ **OR** $½ \times 0.2(0) \times 12^2$	C1

Q27.

Question	Answer	Marks
(a)	*Any three from:* • description of how the (energy from) water is released • mention of transfers between energy stores • (moving) water turns turbine • turbine turns / drives generator • name of method to match description	**B3**
(b)	advantage of generating electricity from energy stored in water	**B1**
	disadvantage of generating electricity from energy stored in water	**B1**
(c)	any **two** from: • geothermal (energy / power) • tidal (energy / power) • nuclear (energy / power)	**B2**

Q28.

Question	Answer	Marks
(a)(i)	no resultant / net force	**B1**
	no resultant/net moment	**B1**
(a)(ii)	4.7×10^7 J or 47 MJ	**A2**
	$(\Delta)E_p = mg(\Delta)h$ **OR** $(\Delta E_p =) mg(\Delta)h$ **OR** $(\Delta E_p =) 3200 \times 9.8 \times 1500$	C1

Q29.

Question	Answer	Marks
(a)	26 J	**A3**
	$E_K = ½mv^2$ **OR** $(E_K =) ½mv^2$ **OR** $(E_K =) ½ \times 0.16 \times (18)^2$	C1
	$(E_K =) ½ \times 0.16 \times (18)^2$ **OR** $(E_K =) ½ \times 0.16 \times 324$ **OR** $(E_K =) 2.6 \times 10^N$	C1

Q30.

Question	Answer	Marks
(a)	2.3 J	**A2**
	Δg.p.e. = $mg\Delta h$ in any form **or** $0.50 \times 10 \times 0.45$	C1

Q31.

Question	Answer	Marks
(a)	(depth =) 0.211 m	**A3**
	$\rho = m / V$ **OR** $(V =) m / \rho$ **OR** 800 / 1020	C1
	$V = l \times w \times d$ **OR** $(d =) V / (l \times w)$ **OR** $V \div 3.72$	C1
(b)	$(\Delta$GPE =) 56(.0) J	**A3**
	GPE = $mg\Delta h$ **OR** (GPE =) $mg\Delta h$ **OR** $(800 / 60) \times 10 \times 0.42(0)$	C1
	(mass per second =) 800 / 60 (kg) **OR** their GPE per minute ÷ 60	C1

Q32.

Question	Answer	Marks
(a)(i)	*any one from*: • fossil fuel / named fossil fuel • biofuel / wood / crops • hydro • wave • wind • solar cell / panel.	**B1**
(a)(ii)	geothermal **OR** nuclear	**B1**
(b)(i)	yes **OR** it is renewable	**B1**
	tides are continuous / regular / happen every day / always there / owtte **OR** Moon / Sun always there **OR** nothing is consumed / used up **OR** tides are an unlimited resource	**B1**
(b)(ii)	(power =) 4800 W	**A4**
	KE = $\frac{1}{2}mv^2$	C1
	(P =) E / t **OR** (P =) KE / s **OR** (KE / s =) $\frac{1}{2} \times 6(.0) \times 10^3 \times 2(.0)^2$	C1
	electrical (output) power = 40% of KE / s **OR** 0.4×12000	C1

Q33.

Question	Answer	Marks
(a)(i)	(E =) 2 200 000 (J) OR 2.2×10^6 (J)	**A3**
	(E =) Pt in any form	C1
	(E =) 600×3600	C1
(a)(ii)	chemical	**B1**
(b)	(t =) 8600 s OR 140 min OR 2.4 h OR 2 h 24 min OR (t =) 8800 s OR 147 min OR 2 h 27 min	**A2**
	(t =) $2.2 \times 10^6 / 250$ OR $(600 \times 60) / 250$ OR $1 \times 600 / 250$	C1
(c)	any **two** from: • less noise OR no noise • less OR no air / gaseous pollution (from the bicycle) OR does not produce acid rain • (the bicycle) uses no / less fossil fuel • does not contribute to greenhouse effect OR does not release CO_2	**B2**

Q34.

Question	Answer	Marks
(a)(i)	straight line begins at (15 s, 120 m) **and** continues to end of given line	**B1**
(a)(ii)	curve with increasing gradient from origin to beginning of candidate's **(a)(i)**	**B1**
(b)	(E_k =) $\frac{1}{2}mv^2$ in any form	**C1**
	$\frac{1}{2} \times 1.8 \times 10^5 \times 20^2$	**C1**
	3.6×10^7 J	**A1**
(c)(i)	(work done =) force × distance (moved in the direction of the force)	**C1**
	(work done =) force × distance moved in the direction of the force	**A1**
(c)(ii)	240 m **c.a.o.**	**B1**
(c)(iii)	$3.6 \times 10^7 / 240$ **or** kinetic energy / distance **or** (a =) 20 / 24 **or** $\Delta v / t$ in any form **or** 0.83 **or** (F =) ma in any form	**C1**
	1.5×10^5 N	**A1**

Q35.

Question	Answer	Marks
(a)	(statement) renewable	**B1**
	(explanation) (wind) is) replaced / replenished OR does not run out OR is not used up OR is an infinite energy resource	**B1**
(b)	any **two** from: geothermal nuclear tidal	**B2**
(c)	chemical	**B1**
	gravitational potential	**B1**

Q36.

(c)(i)	(GPE =) mg (Δ) h (in any form) **or** $0.0021 \times 10 \times 0.80$ **or** $2.1 \times 10 \times 0.80$ **or** 17 (J)	**C1**
	0.017 J	**A1**
(c)(ii)	(KE =) $\frac{1}{2}mv^2$ (in any form)	**C1**
	$\frac{1}{2} \times 0.0021 \times 1.2^2$ **or** $\frac{1}{2} \times 2.1 \times 1.2^2$ **or** 1.5 (J)	**C1**
	1.5×10^{-3} J	**A1**
(c)(iii)	(work done against) friction / drag / resistance **or** thermal energy generated **or** (displaced) liquid gains gravitational potential energy	**B1**

Q37.

Question	Answer	Marks
	(output) $P = VI$ OR $E = VIt$ OR $E = Pt$ in any form words, symbols or numbers OR (P =) VI OR (P =) 240 × 9 OR (P =) 2160 (W) OR (E =) 240 × 9 × 60 = 129 600 (J)	**C1**
	(rate of energy input = 720 000 / 60 =) 12 000 (J / s) OR energy input = 720 000 (J)	**C1**
	(efficiency =) (100 ×) output power / input power OR (100 ×) output energy / input energy words, symbols or numbers	**C1**
	(efficiency =) 100 × {2160 / 12 000}	**C1**
	(efficiency =) 18(%)	**A1**

Q38.

Question	Answer	Marks
(a)	Chemical (potential energy)	**1**
(b)(i)	(E =) m × g × h **OR** 32 × 10 × 2.5	**1**
	800 J	**1**
(b)(ii)	Output power = E ÷ t **OR** 800 ÷ 5.4 **OR** 148.148 (W)	**1**
	Eff. = output (power) ÷ input (power) **OR** $P_{out} \div P_{in}$ **OR** $E_{out} \div E_{in}$ **OR** output power ÷ 0.65 **OR** 148.148 ÷ 0.65 **OR** 800 ÷ 0.65	**1**
	= 230 W	**1**
(c)	Advantage: not dependent on weather/wind blowing **OR** always available	**1**
	Disadvantage: polluting **OR** CO_2/SO_2/greenhouse gases emitted **OR** leads to global warming **OR** oil must be transported **OR** not renewable **OR** oil will run out/be used up	**1**

Q39.

Question	Answer	Marks
(a)	(KE =) ½ × m × v^2	**1**
	(KE =) ½ × 9500 × 75^2	**1**
	(KE =) 2.7 × 10^7 J	**1**