2. Thermal Physics

2.3 Transfer of thermal energy

Paper 3 and 4

Answer Key

Paper 3

Q1.

Question	Answer	Marks
(a)	(heated air) expands	B1
	(becomes) less dense	B1
	less dense air rises OR denser air sinks	B1
(b)(i)	(dull black is) best / better / good emitter owtte	B1
	of radiation / infrared	B1
(b)(ii)	(shiny foil is) best / better / good reflector	M1
	of radiation / infrared	A1

Q2.

Question	Answer	Marks
(a)	idea of measure / read / note / compare how much wax melts (along each rod) **OR** how quickly the wax melts	B1
	idea of: the better the conductor the shorter the length of unmelted wax (remaining) **OR** the better the conductor the further the wax melts (along rod) **OR** the better the conductor the shorter the time for the wax to melt	B1
(b)(i)	(frequency =) 1.5×10^{14} (Hz)	A3
	(frequency =) $3(.0) \times 10^{8} \div 2(.0) \times 10^{-6}$	(C2)
	velocity = frequency × wavelength	(C1)
(b)(ii)	(region) microwaves **OR** radio waves	B1
	valid use that is consistent with radiation in stated region	B1

Q3.

(c)(i)	conduction	B1
(c)(ii)	any **three** from: water particles (at bottom of pan) gain thermal / internal / kinetic energy (water) particles move apart density of liquid decreases OR liquid becomes less dense less dense liquid rises causing liquid to circulate (in pan)	B3
(c)(iii)	100 (°C)	B1

Q4.

Question	Answer	Marks
(a)	conduction AND convection	**B1**
	need a medium / particles (to transfer energy)	**B1**
(b)	any **four** from: water particles gain thermal energy / KE (water) particles move apart warm water becomes less dense less dense water rises / more dense water falls (forming a) convection (current)	**B4**

Q5.

(b)	any **two** pairs (surround container with) insulation / lagging / cotton wool or similar – conduction change material of cup to better insulator – conduction (surround container with) foil / silver / (paint) shiny white – radiation (surround container with) vacuum – conduction OR convection lid – evaporation / convection	**B2**

Q6.

(b)	more energetic particles	**B1**
	particles escape (from the surface (attraction))	**B1**
	so average energy of particles remaining (in liquid) decreases	**B1**

Q7.

Question	Answer	Marks
(a)	air above candle is heated / warms	**B1**
	(air becomes) less dense	**C1**
	less dense air rises (up tube A)	**A1**
(b)	means of heating one end of rods	**B1**
	means of identifying movement of thermal energy along rod	**B1**
	method of comparing materials	**B1**

Q8.

Question	Answer	Marks
(a)(i)	reflects / does not allow transmission of	B1
	infrared / thermal radiation	B1
(a)(ii)	heat loss by conduction cannot take place	B1
	heat loss by convection cannot take place	B1
	because particles are needed for conduction and / or convection	B1
(b)(i)	non-metal	B1
(b)(ii)	metals are good conductors of heat / non-metals are good insulators / poor conductors	B1

Q9.

(b)(i)	conduction	B1
(b)(ii)	Any **three** from: (heat causes) water molecules (to) move further apart OR (hot) water expands / volume increases (hot water) is less dense NOT molecules less dense/expand (so hot / less dense) water rises (and is replaced by cooler / more dense water) convection / current (in water)	B3

Q10.

Question	Answer	Marks
(a)	insulator(s)	B1
(b)	aluminium AND copper	B1
(c)	(one end of both rods) placed in same (type of) heat source means of detecting raised temperature e.g. wax covered rods OR pins attached to rods with wax outcome explained e.g. wax melted further / first on better conductor	B3

Q11.

Question	Answer	Marks
(a)(i)	(shiny surfaces) are good reflectors OR poor absorbers/emitters	B1
	so less thermal energy lost by radiation	B1
(a)(ii)	less (heat lost by) convection	B1
	less (heat lost by) conduction	B1

Paper 4

Q12.

Question	Answer	Marks
(a)	(tarmac / it) absorbs infrared radiation (emitted from the Sun)	**A2**
	(tarmac / it) absorbs radiation / infrared (emitted from the Sun)	C1
(b)	conduction	**B1**
(c)	convection	**B1**
(d)	*any **two** from:* 1 black / tarmac is a better absorber (of radiation) than air 2 tarmac is a poor emitter (at low / this temperature) 3 thin layer of tarmac / very large volume / column of air above road	**B2**

Q13.

Question	Answer	Marks
(a)	(they / particles in ice) vibrate (about a fixed position) **OR** particles in water move throughout the liquid	**B1**
(b)(i)	conduction	**B1**
(b)(ii)	2.6×10^4 J	**A2**
	$c = (\Delta)E / m\Delta\theta$ **OR** ($\Delta E =$) $mc\Delta\theta$ **OR** $0.34 \times 4200 \times 18$ **OR** 2.6×10^N (J)	C1
(b)(iii)	density (of water next to the ice) increases	**B1**
	cold(er) water sinks	**B1**
	warm(er) water replaces cold water **OR** warm(er) water rises **OR** making a convection current	**B1**

Question	Answer	Marks
(b)(iv)	internal energy decreases **AND** (average) kinetic energy (of particles) decreases	**A2**
	kinetic energy decreases	C1

Q14.

Question	Answer	Marks
(a)	*any three from:* • free / delocalised / mobile electrons • (electrons) gain (thermal) energy from hotplate / particles • (electrons) move through(out) copper / metal **OR** (electrons) move to distant particles • electrons transfer energy from higher temperature (region) to lower temperature (region) **OR** (electrons) collide with (distant) particles / transfer energy to (distant) particles	**B3**
(b)	(shiny surfaces are) poor emitters of radiation	**B1**
	reduces energy loss (from the pan / copper) **OR** less energy transferred to surroundings	**B1**
(c)	convection	**B1**

Q15.

Question	Answer	Marks
(a)	infrared	**B1**
(b)(i)	(both) transverse / electromagnetic / travel in a vacuum / have the same (high) speed (in a vacuum)	**B1**
(b)(ii)	(it / visible light) compared with an e.m. radiation stated by candidate in **5(a)** in terms of frequency / wavelength	**B1**
(c)(i)		**B3**
	equipment e.g. black container, white container, thermometers **or** Leslie's cube and detector	B1
	measurements made warm / hot water in container **and** temperature decreases recorded **or** time to reach a given temperature / to cool **or** warm / hot water in cube **and** meter readings recorded	B1
	how a conclusion is reached better emitter surface cools quicker **or** greater reading from better emitter surface	B1

Question	Answer	Marks
(c)(ii)	any **two** appropriate quantities e.g. initial temperature of water mass / volume of water dimensions / surface area of container time of cooling mass of container shape of container smoothness of surface **or** surface area of face (of cube) distance of detector temperature of water at time of measurement smoothness of surface	**B2**

Q16.

(b)	(thermal) radiation	**M1**
	electromagnetic / e-m / infrared / IR (radiation emitted from block)	**A1**
	travels to worker **OR** is absorbed by worker **OR** travels without needing a medium	**A1**
(c)	conduction	**B1**
	delocalised / free / moving electrons	**B1**
	any one from: • (electrons) move (from outer surface) to interior (of rollers) • (electrons) travel through(out) the solid / large distances • (electrons) collide with distant particles • lattice vibrations transfer thermal energy to neighbouring particles **OR** particles vibrate and cause nearby / adjacent particles to vibrate **OR** vibrating particles collide with particles transferring energy.	**B1**

Q17.

(b)	any **three** from: atoms / ions vibrate (vibrating) atoms / ions hit electrons electrons propelled / travelling through metal / moving through metal electrons hit (distant) atoms free electrons / delocalised electrons mentioned	**B3**

Q18.

Question	Answer	Marks
(a)	air good insulator / poor conductor	**B1**
	holder / it stops / reduces conduction OR no / less thermal energy conducted (to hand)	**B1**
	temperature (of outside of holder) lower (than cup) OR less energy to skin / hand / person	**B1**
(b)	(put a) lid / cover (on cup)	**B1**
	mention of convection	**B1**
	less / no convection (from surface)	**B1**
	alternative route for last 2 m.p.s	
	mention of evaporation	**(B1)**
	less / no evaporation (from surface / container)	**(B1)**
(c)	radiation	**B1**

Q19.

Question	Answer	Marks
(a)	electrons mentioned	**B1**
	electrons travel (a great distance) through the metal **or** (vibrating) atoms hit (free) electrons	**B1**
	electrons hit (distant) particles **or** transfer energy (to distant atoms)	**B1**
(b)	shiny surfaces are poor emitters (of radiation)	**B1**
	infrared / radiation / mentioned	**B1**
	less energy lost **or** lost energy does not need to be supplied	**B1**
(c)	less thermal energy emitted **or** less space for energy to be lost	**B1**