



## Black Body Radiation

Name: \_\_\_\_\_

Class: \_\_\_\_\_

Date: \_\_\_\_\_

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Time: **174 minutes**

Marks: **174 marks**

Comments:

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## Mark schemes

1	(a)	dark matt	1
		light shiny	1
	(b)	B A C	1
		biggest temperature difference (80 °C) <i>dependent on first mark</i>	1
	(c)	(i) (the can that is) dark matt	1
		best absorber (of infrared radiation)	1
		(ii) any <b>three</b> from:	
		<ul style="list-style-type: none"><li>• same area / shape of can</li><li>• surrounding temperature is the same for all cans</li><li>• same surface underneath cans</li><li>• same position in the room</li></ul>	3
	(d)	fox A	
		smaller ears	1
	thicker fur	1	
	these minimise energy transfer <i>dependent on first 2 marks</i>	1	
		<b>[12]</b>	
2	(a)	(black) is a good absorber of (infrared) radiation	1
	(b)	(i) amount of energy required to change (the state of a substance) from solid to liquid (with no change in temperature) <i>melt is insufficient</i>	1
		unit mass / 1kg	1

- (ii)  $5.1 \times 10^6$  (J)  
*accept  $5 \times 10^6$*   
*allow 1 mark for correct substitution ie  $E = 15 \times 3.4 \times 10^5$*  2
- (c) (i) mass of ice  
*allow volume / weight / amount / quantity of ice* 1
- (ii) to distribute the salt throughout the ice 1
- to keep all the ice at the same temperature 1
- (iii) melting point decreases as the mass of salt is increased  
*allow concentration for mass*  
*accept negative correlation*  
*do **not** accept inversely proportional* 1
- (d) 60 000 (J)  
*accept 60 KJ*  
*allow 2 marks for correct substitution ie  $E = 500 \times 2.0 \times 60$*   
*allow 2 marks for an answer of 1000 **or** 60*  
*allow 1 mark for correct substitution ie*  
 *$E = 500 \times 2.0$  **or**  $0.50 \times 2.0 \times 60$*   
*allow 1 mark for an answer of 1* 3

- (e) Marks awarded for this answer will be determined by the Quality of Communication (QC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

**0 marks**

No relevant content

**Level 1 (1–2 marks)**

There is *an attempt at a description of some advantages or disadvantages.*

**Level 2 (3–4 marks)**

*There is a basic description of some advantages **and / or** disadvantages for some of the methods*

**Level 3 (5–6 marks)**

There is a clear description of the advantages and disadvantages of all the methods.

**examples of the points made in the response**

***extra information***

**energy storage**

advantages:

- no fuel costs
- no environmental effects

disadvantages:

- expensive to set up and maintain
- need to dig deep under road
- dependent on (summer) weather
- digging up earth and disrupting habitats

**salt spreading**

advantages:

- easily available
- cheap

disadvantages:

- can damage trees / plants / drinking water / cars
- needs to be cleaned away

**undersoil heating**

advantages:

- not dependent on weather
- can be switched on and off

disadvantages:

- costly
- bad for environment

6  
[18]

3

(a) infrared / IR

*correct answer only*

1

(b) any **two** from:

- increase the power / watts  
*allow increase the temperature of the oven or make the oven hotter*
- decrease the speed  
*allow leave the biscuits in for longer*
- put biscuits through again  
*increase radiation is insufficient*  
*ignore changes to the design of the oven*

2

(c) (inside) surface is a (good) reflector or poor absorber (of IR)

*Ignore bounce for reflect*

*surface is a (good) reflector of light does not score*

*surface is a (good) reflector of light and infrared / heat does score*

1

(and) outside surface is poor emitter (of IR)

1

(so) increases the energy reaching the biscuits

*allow reduces energy loss or makes oven more efficient*

*do **not** accept no energy losses*

*keeps oven hotter is insufficient*

1

[6]

4

(a) to reflect (the infrared)

*accept (shiny surfaces) are good reflectors*

*ignore reference to incorrect type of wave*

1

(b) black

1

best absorber (of infrared)

*answer should be comparative*  
*black absorbs (infrared) is insufficient*  
*accept good absorber (of infrared)*  
*ignore reference to emitter*  
*ignore attracts heat*  
*ignore reference to conduction*

1

(c) to reduce energy loss

*accept to stop energy loss*  
*accept heat for energy*  
*accept to stop / reduce convection*

**or**

so temperature of water increases faster

*accept to heat water faster*  
*accept cooks food faster*

**or**

reduces loss of water (by evaporation)

1

(d) 672 000

*allow 1 mark for correct substitution, ie  $2 \times 4200 \times 80$  provided no subsequent step shown*

2

**[6]**

**5**

(a) (matt) black is a good emitter of infrared / radiation

*accept heat for infrared / radiation*  
*ignore reference to good absorber*  
*attracts heat negates this marking point*

1

to give maximum (rate of) energy transfer (to surroundings)

*accept temperature (of coolant) falls fast(er)*  
*accept black emits more radiation for 1 mark*  
*black emits most radiation / black is the best emitter of radiation for 2 marks*

1

(b) the fins increase the surface area

*accept heat for energy*

1

so increasing the (rate of) energy transfer

**or**

so more fins greater (rate of) energy transfer

1

(c) 114 000

*allow 1 mark for correct temperature change, ie 15 (°C)*

**or**

*allow 2 marks for correct substitution, ie  $2 \times 3\,800 \times 15$*

*answers of 851 200 or 737 200 gain 2 marks*

**or**

*substitution  $2 \times 3800 \times 112$  or  $2 \times 3800 \times 97$  gains 1 mark*

*an answer of 114 kJ gains 3 marks*

3

(d) increases the efficiency

1

less (input) energy is wasted

*accept some of the energy that would have been wasted is (usefully) used*

**or**

more (input) energy is usefully used

*accept heat for energy*

1

[9]

6

(a) (i) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light

*accept as a control / comparison*

*to measure room temperature is insufficient*

1

(ii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures

- red light produces the greatest heating effect / (rise in) temperature

**or**

- violet produces the least heating effect / (rise in) temperature

- all colours produce a greater heating effect than outside the spectrum  
*an answer*

*the longer the wavelength the greater the (rise in) temperature*

**or**

*the lower the frequency the greater the (rise in) temperature gains both marks*

2



- (b) move a thermometer into the infrared region / just beyond the red light  
*allow use an infrared camera / infrared sensor* 1
- the temperature increases beyond 24(°C)  
*accept temperature higher than for the red light* 1
- (c)  $v = f \times \lambda$
- $9.4 \times 10^{-6}$   
*accept  $9.375 \times 10^{-6}$  or  $9.38 \times 10^{-6}$*
- or**
- 0.0000094  
*accept 0.000009375*  
**or** *0.00000938*  
*allow 1 mark for correct substitution*  
*ie  $3 \times 10^8 = 3.2 \times 10^{13} \times \lambda$*  2
- (d) at night the surroundings are cooler  
*accept at night the air is colder*  
*there is no heat from the Sun is insufficient*
- or**
- at night there is a greater temperature difference between people and surroundings 1
- (so surroundings) emit less infrared (than in daytime)  
*accept camera detects a greater contrast*
- or**
- gives larger difference in infrared emitted (between people and surroundings) 1

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7

(a) any **two** from:

- black is a good emitter of (infrared radiation)  
*accept heat for radiation*  
*ignore reference to absorbing radiation*
- large surface (area)
- matt surfaces are better emitters (than shiny surfaces)  
*accept matt surfaces are good emitters*  
*ignore reference to good conductor*

2

(b) 90% or 0.9(0)

$$\text{efficiency} = \frac{\text{useful energy out} (\times 100\%)}{\text{total energy in}}$$

*allow 1 mark for correct substitution, ie  $\frac{13.5}{15}$*

*provided no subsequent step shown*

*an answer of 90 scores 1 mark*

*an answer of 90 / 0.90 with a unit scores 1 mark*

2

(c) (producing) light

*allow (producing) sound*

1

(d) any **two** from:

- wood is renewable  
*accept wood grows again / quickly*  
*accept wood can be replanted*
- (using wood) conserves fossil fuels  
*accept doesn't use fossil fuels*
- wood is carbon neutral  
*accept a description*  
*cheaper / saves money is insufficient*

2

(e)  $E = m \times c \times \theta$

2 550 000

*allow 1 mark for correct substitution  
ie  $100 \times 510 \times 50$   
provided no subsequent step shown  
answers of 1 020 000, 3 570 000 gain 1 mark*

2

joules /J

*accept kJ / MJ  
do **not** accept j  
for full credit the unit and numerical answer must be consistent*

1

[10]

8

(a) (i) The volume of boiling water.

1

(ii) any **one** from:

- (more) precise  
*do **not** accept better (reading)*
- accurate
- reliable  
*do **not** accept thermometer is unreliable*
- removes human / reading error  
*accept easier to read  
accept take temperature more frequently*

1

(b) **B**

*marks are for the explanation*

temperature falls faster

*this mark point cannot score if **A** chosen*

1

because black is a better / good emitter

*ignore reference to better absorber  
accept for both marks an answer in terms of why **A** is the white can*

1

(c) (i) faster than

1

(ii) darker / black surfaces absorb heat faster  
*accept black is a better / good absorber*  
*dark surfaces attract heat negates this mark* 1

(iii) air is a bad / poor conductor  
**or**  
air is a good insulator  
*accept air is an insulator* 1

[7]

9

(a) (i) convection 1

(ii) conduction 1

(b) (i) 2 1

black is the best absorber (of thermal energy / heat)  
*accept black is the best emitter (of thermal energy / heat)*  
*note that a comparative is needed (eg better or best)* 1

(ii) the colour of the metal plates 1

(iii) any **one** from:  

- more precise / accurate / reliable  
*do **not** accept better reading*  
*do **not** accept thermometer is unreliable*
- can measure continuously
- take many readings in a small time
- removes (human) reading error  
*accept easier to read*
- can compare / draw graphs automatically
- records data automatically

 1

(c) (i) radiation 1  
*accept radiates*  
*accept infra red (IR) waves*  
*do **not** accept heat waves*

- (ii) to reflect (heat away from the fire fighter)  
*accept it reflects*  
*accept it is a poor absorber (of thermal radiation / heat)*  
*do **not** accept deflect / bounce for reflect*

1

(d) **N**

*the mark is for the reason which does not score if **M** is chosen*

transfers / absorbs less heat

**or**

gives smallest increase in temperature

*accept will keep fire fighters cooler*

*accept **N** is cooler (after 15 minutes)*

*an answer **N** goes up to 52°C and **M** goes up to 100°C is insufficient*

1

[9]

10

- (i) *this mark only scores if a correct pair is chosen **and** a correct reason given*

**A and C**

*both required and none other*

**or**

**B and D**

*both required and none other*

only one (independent) variable

**or**

different shapes but the same colour

*accept only the shape changes*

1

- (ii) **B radiates** heat faster

*converse answer in terms of **A** gains full marks*

1

**or**

B is a better emitter (of heat)

but B has a smaller (surface) area

**or**

B has a smaller (surface) area: volume ratio

*allow **2** marks for both lose the same quantity / amount of heat in the same time*

***or** both have same rate of heat loss*

*allow **1** mark for both lose the same quantity / amount of heat*

1

(iii) any **one** from:

- transfer a lot of heat (too rapidly)
- water temperature drops too rapidly  
*accept (significantly) more heat will be lost from the first radiator*
- water too cold for the next radiator  
*mention of absorption of heat negates mark*

1

[4]

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(a) (i) radiation

*ignore thermal / infrared*

1

(ii) black is a better / good absorber (of heat / radiation)

*ignore reference to black being a good emitter*

*black absorbs heat is insufficient*

*do **not** accept black attracts / absorbs the Sun*

*do **not** accept black attracts heat*

1

(so) temperature rises faster

*must be an indication of heating up quicker*

**or**

white is a worse / poor absorber (of heat / radiation) (1)

*accept white is a better / good reflector (of heat / radiation)*

(so if white faces) temperature would rise slower (1)

*ignore any reference to light*

1

(b) (i) 1.2 (hours) **or** 1 hour 12 minutes

*no tolerance*

1

(ii) increases (rapidly at first then increases at a slower rate)

*do **not** accept increases at a steady rate*

1

- (c) (i) any **two** from:
- (fill with) same mass / volume / amount of water
  - same level of (sun)light / sunshine  
*accept same heat / light source*  
*accept same place*
  - outside for the same (length of) time
  - outside at same time (of day / year)
  - initial water temperature
  - the side of the bag facing the Sun  
*do **not** accept any factors to do with the construction of plastic bags*  
*eg thickness*
- 2
- (ii) curved line drawn above given line  
*both lines must start from the same point*  
*ignore if continues beyond one hour or levels off after 1 hour*  
*do **not** accept a straight line*
- 1

[8]

12

- (a) (i) silvered surfaces  
*more than the correct number of ticks in a row negates the mark*
- radiation
- 2
- plastic cap
- conduction, convection (both required)

	conduction	convection	radiation	
vacuum	✓	✓		
silvered surfaces			✓	(1)
plastic cap	✓	✓		(1)

(ii)

*any mention of air or any other substance in a vacuum scores zero*

because there are no particles in a vacuum

*accept atoms / molecules for particles*

*accept vacuum is empty space*

*accept there is nothing in a vacuum*

*accept there is no air / gas in the vacuum*

conduction **and** convection need particles / medium

*need reference to both conduction **and** convection*

*accept correct descriptions*

2

(b) (i) less heat lost (to air above the heater)

*do **not** accept **no** heat lost*

light shiny surfaces are poor emitters (of radiation)

*accept radiators for emitters*

*references to reflection are neutral*

**or** dull, matt surfaces are good emitters (of radiation)

*do **not** credit answers which infer reflection from the underside of the hood*

*ignore correct reference to absorption*

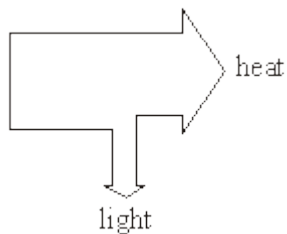
2

(ii) correct diagram drawn with one output arrow narrower than the other

*ignore input*

arrows correctly labelled with energy form

eg



*flow charts score zero*

2

(iii) energy cannot be destroyed

*accept (principle of) conservation of energy*

*do **not** accept because energy cannot be lost without clarification*

1

[9]



13

(a) the bigger the surface area, the faster the water cools down / temperature falls

*answers must imply rate*

*accept heat for temperature provided rate is implied*

*do **not** accept cools down more unless qualified*

1

(b) any **two** from:

the ears:

- have large surface / area

*not just has large ears*

- radiate heat

*accept loses heat, but does not score*

*if the reason given for heat loss is wrong*

- keep blood cooler

2

(c) (i) radiation

1

(ii) conduction

1

[5]

14

(a) conduction

*do **not** accept conductor*

1

(b) the freezer

*both parts needed*

greater temperature difference (between freezer and room)

*do **not** accept because it is the coldest*

1

(c) any **two** from:

- poor absorber of heat / radiation

*accept does not absorb heat poor emitter of heat / radiation is neutral*

- reflects heat / radiation (from room away from fridge-freezer)

- reduces heat transfer into the fridge-freezer

- reduces power consumption of fridge-freezer

*do **not** accept it is a bad conductor / good insulator*

2

[4]

15

- (a) (i) 25 (%)  
*do not accept ¼* 1
- (ii) increases 1
- (b) tick (✓) in top and bottom box  
*both required* 1
- (c) SHINY surfaces are good reflectors of infra-red radiation  
*accept white for shiny*  
**or** black surfaces are POOR reflectors of infra-red radiation  
*accept bad for poor*  
*accept insertion of 'not' before 'good' in statement*  
**or** black surfaces are good EMITTERS of infra-red radiation  
**or** black surfaces are good ABSORBERS of infra red radiation 1

[4]

16

- (a) the outside colour of the cans 1
- (b) (i) 18 (°C) **or** 88 to 70  
*ignore negative sign* 1
- (ii) 8 (°C) **or** 70 to 62  
*ignore negative sign* 1
- (c) greater temperature difference between water and surroundings (at start)  
*must mention temperature difference*  
*ignore just water hotter*  
*accept energy used to heat cans initially* 1

- (d) black 1
- temperature falls the fastest (in L)  
*accept (can L) loses more heat / cools quicker*  
*accept heat for temperature* 1
- black is a good / the best / better emitter (of heat / radiation)  
*accept converse*  
*ignore black is best absorber* 1

[7]

17

- (a) ions / electrons gain (kinetic) energy  
*accept atom / particles / molecules for ion*  
*accept ions vibrate faster*  
*accept ions vibrate with a bigger amplitude*  
*accept ions vibrate more*  
*do not accept ions move faster* 1
- (free) electrons transfer energy by collision with ions  
**or** energy transferred by collisions between vibrating ions 1
- (b) move faster or take up more space  
*do not accept start to move / vibrate* 1
- (warmer) water expands **or** becomes less dense (than cooler water)  
*do not accept answers in terms of particles expanding* 1
- warm water rises (through colder water) **or** colder water falls to take its place 1
- (c) transfer of energy by waves / infrared (radiation)  
*accept rays for waves*  
*do not accept transfer of energy by electromagnetic waves*  
*ignore reference to heat* 1

[6]

18

- (a) (i) vacuum  
*do not allow stopper* 1
- (ii) (absence of particles) means no (transfer of energy between) particles for conduction  
*accept particles or atoms or molecules or electrons* 1

no movement of molecules for (transfer of energy by) convection

*accept particles/atoms/electrons*

*if answer to (a)(i) is correct: then in (a)(ii) have stated*

*'conduction and convection both need a medium/particles/materials'*

*= 2 marks*

*(If medium is specified, it must be correct, conduction can be solid, liquid or gas, convection must be liquid or gas)*

*if answer to (a)(i) is incorrect then in (a)(ii) have stated 'conduction and convection both need a medium...' = 1 mark, unless further qualified by stating about absence of particles, in which case get a second mark.*

1

(b) (i) silvered surface

*accept silver surface*

1

(ii) silvered is a bad emitter/radiator

1

surface reflects heat/energy/radiation (at inner and outer surface)

**or** is a bad absorber (of energy)

*accept bounces off*

1

[6]

19

(i) radiation **or** infra red

*do **not** accept rays*

*do **not** accept waves*

*accept electromagnetic waves*

1

(ii) good absorber (of heat) to absorb heat (**or** infrared)

*do **not** accept 'attract' **or** 'capture' **or** soak*

1

(iii) reduce heat loss (from the panel)

*accept (good) (heat) insulator*

*accept stop **or** reduce conduction*

*accept stop **or** reduce convection*

*accept traps heat*

*accept keeps water hot*

1

(iv) to reflect (back into the panel) heat **or** infrared **or** Sun's energy

*do **not** accept 'bouncing'*

*do **not** accept reflect Sun*

*do **not** accept reflect sunlight **or** sun's rays*

1

radiated **or** given out by the (black) pipe

*accept back to pipe*

*accept reduce heat loss for 1 mark*

*accept reduce heat loss by radiation for 2 marks*

*accept stop heat loss by radiation for 1 mark*

1

[5]

20

(a) (i) Carries heat up (as convection current)

1

(ii) (1) By conduction or from molecule to molecule  
(2) By radiation or as IR

2

(iii) Use shiny surface (inside or outside) or small area

1

(b) (i) Rise more quickly

1

(ii) Dull surface good absorber  
(accept "attract" = "absorb" if context correct,  
then penalise spg mark.

Shiny surface poor absorber

2

(c) (i) Fall more quickly

1

(ii) Dull surface good emitter  
Shiny surface poor emitter

2

[10]

21

(a) convection

air is heated by the burner / particles gain energy

air expands / particles move about more / particles move faster

air becomes less dense / particles are more spread out

air rises / particles rise - *not* heat rises

air from C moves into the heater / particles from C move into the heater to  
replace it / them

*any four for 1 mark each*

4

- (b) (i) radiation  
*for one mark* 1
- (ii) black surface radiates / emits well  
(allow absorbs and emits well) (allow comparison with shiny / white surfaces)
- large surface area needed  
high temperature (of the lumps)  
*any one for 1 mark* 1

[6]

22

- absorber 1
- reflector 1
- emitter 1

[3]

23

- (i) D, C **or** B, in either order, then A  
*tick or cross on the A* 1
- (ii) matt absorbs energy (better than shiny)  
*the converse arguments are acceptable* 1
- black absorbs energy (better than white) 1

[3]

24

- (a) radiates  
absorbs / conducts  
reflects  
*for 1 mark each* 3
- (b) C make sure the lamp is the same distance from both tubes  
B switch on the lamp  
A switch off the lamp  
E wait for the temperature to stop rising  
D read the thermometers  
*for 1 mark each* 5

[8]