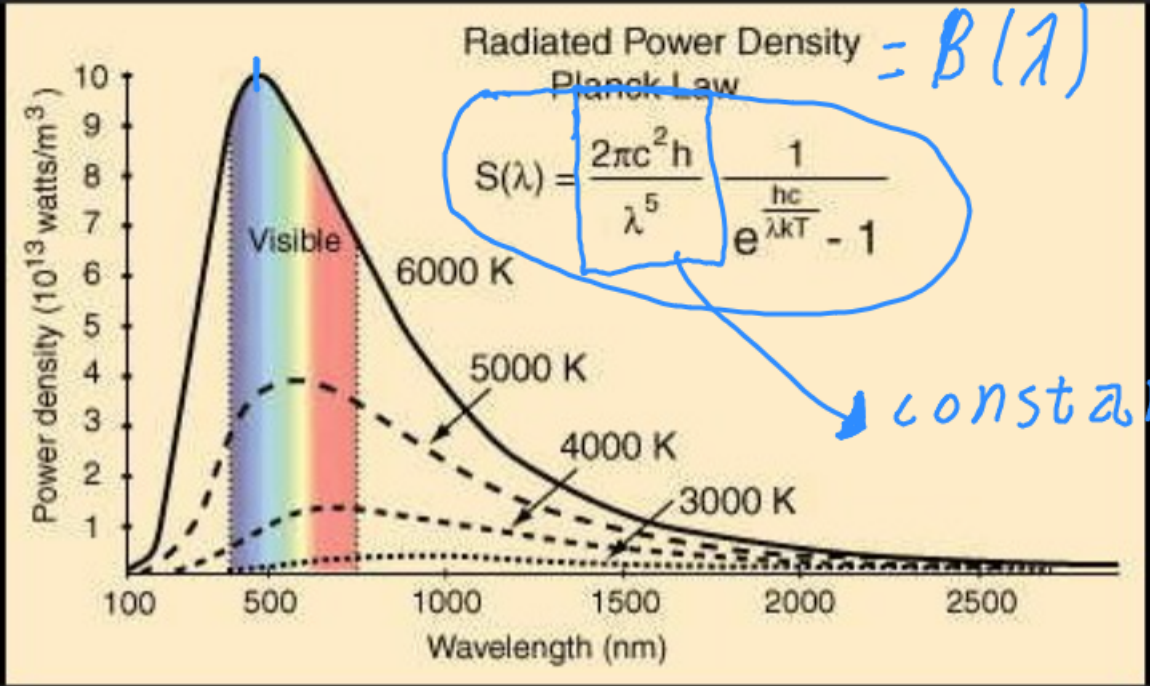

$= B(\lambda)$

constant

$3 \cdot 10^8 ms^{-1}$

c = speed of light

h = planck constant

K = coulomb constant

Planck's Radiation curve for black bodies at various temperatures [2]. | Download Scientific Diagram

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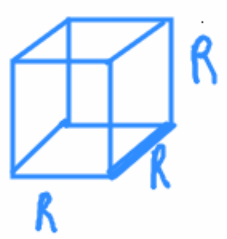
40 $L_{sphere} = \cancel{\sigma} \cdot A_{sphere} \cdot \cancel{T^4}$ over $L_{cube} = \cancel{\sigma} \cdot A_{cube} \cdot \cancel{T^4}$ $= \dfrac{4 \cdot \pi \cdot \cancel{R^2}}{6 \cdot \cancel{R^2}} = \dfrac{2\pi}{3} = 2.1 \Leftrightarrow$

$\boxed{L_{sphere} = 2.1\ L_{cube}}$

Because geometrically it is a more perfect - balanced shape.



$Q = mL$

$\dfrac{\Delta Q}{\Delta t} = kA\dfrac{\Delta T}{\Delta x}$

$L = \sigma A T^4$

$b = \dfrac{L}{4\pi d^2}$

$\boxed{\lambda_{max} T = 2.9 \times 10^{-3}\,\text{mK}}$

… radiated per unit area σT^4

… tered power

… dent power

$\dfrac{L_{old}}{L_{new}} = \dfrac{\cancel{\sigma} \cdot \cancel{A} \cdot T_{old}^4}{\cancel{\sigma} \cdot \cancel{A} \cdot T_{new}^4}$

$\dfrac{L_{old}}{L_{new}} = \dfrac{323^4}{373^4} = \left(\dfrac{323}{373}\right)^4 \Rightarrow$

$L_{new} = L_{old} \cdot \left(\dfrac{373}{323}\right)^4$

$L_{new} = 1.78\ L_{old}$

factor.

37 $\lambda_{max} \cdot T = 2.9 \cdot 10^{-3}\,mK$

$410 \cdot 10^{-9}\,\cancel{m}\ T = 2.9 \cdot 10^{-3}\,\cancel{m} \cdot K$

$T = \dfrac{2.9 \cdot 10^5}{41} = 7073\,K.$

38 $T_{480} = \dfrac{2.9 \cdot 10^{-3}}{480 \cdot 10^{-9}} =$

$T_{560} = \dfrac{2.9 \cdot 10^{-3}}{560 \cdot 10^{-9}} =$

$T_{480} > T_{560}.$

CONTINUED

34 A cylindrical metallic rod has radius 1.0 cm and length 25 cm. One end of the rod is placed into a large chunk of ice at 0 °C and the other in boiling water at 100 °C. The thermal conductivity of the rod is 350 W m^{-1} K^{-1}. Estimate how long it will take to melt 1 g of ice. It takes about 334 J to melt 1 g of ice at 0 °C.

35 Calculate the ratio of the power radiated per unit area from two black bodies at temperatures 900 K and 300 K.

36 **a** State what you understand by the term *black body*.

b Give an example of a body that is a good approximation to a black body.

c By what factor does the rate of emitted radiation from a body increase when the temperature is raised from 50 °C to 100 °C?

37 A star radiates like a black body. Most of the energy is emitted at a wavelength of 410 nm. What is the surface temperature of the star?

38 Star X has peak wavelength 480 nm and star Y has peak wavelength 560 nm. Which star has the higher surface temperature?

39 The surface area and kelvin temperature of a black body are both doubled. By what factor do:

a the radiated power

b the radiated intensity

increase?

40 A sphere of radius R and a cube of side R radiate like black bodies. The sphere and the ~~cube are at the same temperature~~. Which body loses more energy per second?

41 The graph (Figure 7.16) shows a black-body spectrum.

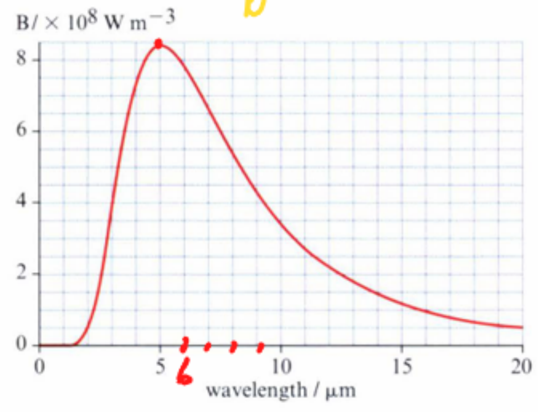


Figure 7.16: For question 41.

a Determine the temperature of the black body.

b The kelvin temperature of the black body in **a** is doubled. What is the peak wavelength?

c The area of the body in **a** is reduced, but the temperature stays the same as that found in **a**. Draw a graph to show the new black-body spectrum.
(**Hint:** what does the area represent?)

41 a Wien's Law:

$\lambda_{max} \cdot T = 2.9 \cdot 10^{-3}\,mK$

$6 \cdot 10^{-6}\,\cancel{m} \cdot T = 2.9 \cdot 10^{-3}\,\cancel{m}K$

$\boxed{T = 483\,K}$

82 Faefbf 02 C 5 47 E 5 A 07 | Physics - K.A. Tsokos - Seventh Ed

50

$$\frac{b_A}{b_B} = \frac{8\cdot 10^{-13}\ W\ m^{-2}}{2\cdot 10^{-15}\ W\ m^{-2}} = \frac{8\cdot 10^{-13}\cdot 10^{15}}{2} = 4\cdot 10^{2} = 400$$

$$\frac{b_A}{b_B} = 400 \Rightarrow \frac{\frac{L_A}{4\pi d_A^2}}{\frac{L_B}{4\pi d_B^2}} = 400$$

$$\frac{L_A\cdot d_B^2}{L_B\cdot d_A^2} = 400 \Rightarrow$$

$$\frac{L_A\cdot 4^2\cdot 30^2}{L_B\cdot 5^2\cdot 30^2} = 400 \Rightarrow \frac{L_A}{L_B} = \frac{25\cdot 400}{16} \Rightarrow$$

$$\sqrt[4]{\frac{\sigma\cdot A\cdot T_A^4}{\sigma\cdot A\cdot T_B^4}} = \sqrt[4]{\frac{10\,000}{16}} \Rightarrow \frac{T_A}{T_B} = 5$$

$$\boxed{\frac{T_A}{T_B} = 5}$$

TEST YOUR UNDERSTANDING

Talking: Mr Alex

$$b_A = 2\cdot b_B \Rightarrow$$

$$\frac{L_A}{4\pi d_A^2} = 2\cdot\frac{L_B}{4\pi d_B^2}$$

$$2\, d_A^2 = d_B^2$$

$$\frac{d_A}{d_B} = \sqrt{\frac{1}{2}}$$

$$\frac{d_A}{d_B} = \frac{\sqrt{2}}{2}$$

49 Two stars have the same luminosity. Star A has a surface temperature of 5000 K, and star B a temperature of 10 000 K.

a Suggest which is the larger star and by how much.

b The apparent brightness of A is double that of B; calculate the ratio of the distance of A to that of B.

$$L_A = L_B \Leftrightarrow$$

$$\sigma\cdot A_A\cdot T_A^4 = \sigma\cdot A_B\cdot T_B^4$$

$$A_A\cdot 5000^4 = A_B\cdot 2^4\cdot 5\text{[redacted]} \Rightarrow \boxed{A_A = 16\cdot A_B}$$

50 Star A has apparent brightness 8.0×10^{-13} W m^{-2} and its distance is 120 ly. Star B has apparent brightness 2.0×10^{-15} W m^{-2} and its distance is 150 ly. The two stars have the same size. Calculate the ratio of the temperature of star A to that of star B.

51 Take the surface temperature of our sun to be 6000 K and its luminosity to be 3.9×10^{26} W. Find, in terms of the solar radius, the radius of a star with:

a temperature 4000 K and luminosity 5.2×10^{28} W

b temperature 9250 K and luminosity 4.7×10^{27} W.

52 Two stars, X and Y, have the same apparent brightness and temperature. The distance to X is double the distance to Y. What is the ratio of radii $\frac{R_X}{R_Y}$?

53 a Describe how the colour of the light from a star can be used to determine the surface temperature of the star.

b A star appears blue and another appears red. Which is hotter?

54 Stars A and B emit most of their light at wavelengths of 650 nm and 480 nm, respectively. Star A has twice the radius of star B. Find the ratio of the luminosity of star A to that of B.

B.2 Greenhouse effect	emissivity $= \frac{\text{power radiated per unit area}}{\sigma T^4}$ albedo $= \frac{\text{total scattered power}}{\text{total incident power}}$
B.3 Gas laws	

$A = 16\cdot B$

50 Star A has apparent brightness 8.0×10^{-13} W m^{-2} and its distance is 120 ly. Star B has apparent brightness 2.0×10^{-15} W m^{-2} and its distance is 150 ly. The two stars have the same size. Calculate the ratio of the temperature of star A to that of star B.

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b A star appears blue and another appears red. Which is hotter?

54 Stars A and B emit most of their light at wavelengths of 650 nm and 480 nm, respectively. Star A has twice the radius of star B. Find the ratio of the luminosity of star A to that of star B.

54

$$\begin{cases} \lambda_A = 650 \cdot 10^{-9}\,m \\ \lambda_B = 480 \cdot 10^{-9}\,m \end{cases}$$

$$r_A = 2 r_B$$

$$T_A \cdot \lambda_A = T_B \cdot \lambda_B$$

(by Wien's Law)

$$\frac{T_A}{T_B} = \frac{\lambda_B}{\lambda_A}$$

$$\left(\frac{T_A}{T_B}\right)^4 = \left(\frac{48\cancel{0} \cdot \cancel{10^{-9}}}{65\cancel{0} \cdot \cancel{10^{-9}}}\right)^4$$

$$\frac{T_A^4}{T_B^4} = \frac{48^4}{65^4}$$

$$\frac{\sigma \cdot 4\pi \cdot R_A \cdot T_A^4}{\sigma \cdot 4\pi \cdot 2R_B \cdot T_B^4} = \frac{48^4}{65^4} \Rightarrow$$

$$\frac{L_A}{L_B \cdot 2} = \frac{48^4}{65^4}$$

$$\boxed{\frac{L_A}{L_B} = 0.595}$$

52

$$b_x = b_y$$

$$\frac{L_x}{\cancel{4\pi}\, d_x^2} = \frac{L_y}{\cancel{4\pi}\, d_y} \Leftrightarrow \frac{\cancel{\sigma} \cdot A_x \cdot T_x^4}{d_x^2} = \frac{\cancel{\sigma} \cdot A_y \cdot T_y^4}{d_y^2}$$

$$\Leftrightarrow \frac{\cancel{4\pi} \cdot R_x^2 \cdot \cancel{T_x^4}}{d_x^2} = \frac{\cancel{4\pi} \cdot R_y^2 \cdot \cancel{T_y^4}}{d_y^2}$$

$$\frac{R_x}{R_y} = \sqrt{\frac{d_x^{\cancel{2}}}{d_y^{\cancel{2}}}} = \frac{d_x}{d_y} = \frac{2 \cdot \cancel{d_y}}{\cancel{d_y}} = 2$$

b

We know by definition that a blue star is hotter, compared to a red star however:

$$\begin{cases} \lambda_{red} = 685 \cdot 10^{-9}\,m \\ \lambda_{blue} = 473 \cdot 10^{-9}\,m \end{cases}$$

$$T_{red} \cdot \lambda_{red} = 2.898 \cdot 10^{-3}\,mK \Rightarrow \boxed{T_{red} = 4234K}$$

$$T_{blue} \cdot \lambda_{blue} = 2.898 \cdot 10^{-3}\,mK$$

$$\boxed{T_{blue} = 6131\,K}$$

we can find the tempera[...] wavelength (aka colour) [...]

53 a

$$\lambda_{max} \cdot T = 2.898 \cdot 10^{-3}\,mK$$

we know that by wien's Law, each colour gives a different wavelength. By knowing the

Talking: Mr Alex

GUIDING QUESTION

What is the mechanism by which the earth maintains a constant average temperature?

Introduction

An important application of the black-body radiation law is to the energy balance of the earth. The earth receives energy from the sun but also partly reflects and partly radiates this energy back into space. This keeps the average earth temperature roughly constant. This phenomenon allows life on earth to be sustained—so it is an important area of study.

8.1 Radiation from real bodies

Black bodies are idealized bodies. Real bodies radiate according to the modified Stefan–Boltzmann law: $P = e\sigma AT^4$. The constant e is known as the **emissivity** of the surface. Its value is between 0 and 1; the value $e = 1$ corresponds to the idealized black body.

Emissivity is the ratio of the power per unit area radiated by a body to the power per unit area radiated by a black body of the same temperature.

KEY POINT

The power radiated per unit area is called (radiated) intensity and so equals $I = e\sigma T^4$.

The unit of intensity is $W\,m^{-2}$.

Unlike a black body that absorbs all the radiation incident on it, reflecting none, a real body will reflect some of the incident radiation. The ratio of the reflected intensity (or power) to the incident intensity (or power) is called the **albedo** of the body.

KEY POINT

Albedo is the ratio $\alpha = \dfrac{\text{total reflected power}}{\text{total incident power}}$.

Albedo has no unit.

For a body that can only absorb or reflect (i.e. it cannot *transmit*) the emissivity and albedo are related by $e + \alpha = 1$.

Consider a body of emissivity e and surface temperature T whose surroundings have a temperature T_s. The surroundings may be assumed to be a black body. The body radiates an intensity $e\sigma T^4$. The surroundings radiate an intensity σT_s^4. Of this intensity the body will *reflect* a fraction $\alpha\sigma T_s^4$ and so will *absorb* a fraction $(1-\alpha)\sigma T_s^4$, i.e. $e\sigma T_s^4$. The *net intensity* for the body is then $I_{net} = e\sigma T^4 - e\sigma T_s^4$. Thus the rate at which energy leaves the body (the power) of surface area A is

$$P_{net} = e\sigma A(T^4 - T_s^4)$$

At equilibrium no net power leaves the body and so $T = T_s$, as we might expect. Table 8.1 gives values for the emissivity of various surfaces.

Surface	Emissivity
black body	1
ocean water	0.8
ice	0.1
dry land	0.7
land with vegetation	0.6

Table 8.1: Emissivity of various surfaces.

Figure 8.1 shows the variation of the spectral intensity B with wavelength λ from various different surfaces kept at the same temperature (300 K). The difference in the curves is due to the different emissivities (e = 1.0, 0.8 and 0.2). The curves are identical apart from an overall factor that shrinks the height of the curve as the emissivity decreases. The peak wavelength is the same for all three curves because the temperature is the same.

$$e = \frac{P}{\sigma \cdot A \cdot T^4}$$

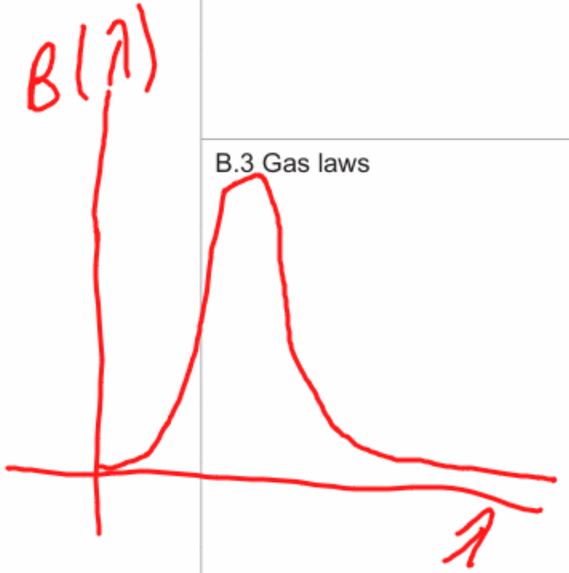
$P < L$

$P < \sigma \cdot A \cdot T^4$

$e \in (0,1)$

B. The particulate nature of matter

Standard level and higher level	
B.1 Thermal energy transfers	$\rho = \dfrac{m}{V}$ $\overline{E}_k = \dfrac{3}{2}k_B T$ $Q = mc\Delta T$ $Q = mL$ $\dfrac{\Delta Q}{\Delta t} = kA\dfrac{\Delta T}{\Delta x}$ $L = \sigma AT^4$ $b = \dfrac{L}{4\pi d^2}$ $\lambda_{max}T = 2.9 \times 10^{-3}\,mK$
B.2 Greenhouse effect	$\text{emissivity} = \dfrac{\text{power radiated per unit area}}{\sigma T^4}$ $\text{albedo} = \dfrac{\text{total scattered power}}{\text{total incident power}}$
B.3 Gas laws	[redacted]



TEST YOUR UNDERSTANDING

1 The graph (Figure 8.2) shows the variation with wavelength of the spectral intensity of radiation emitted by two bodies of identical shape and size.

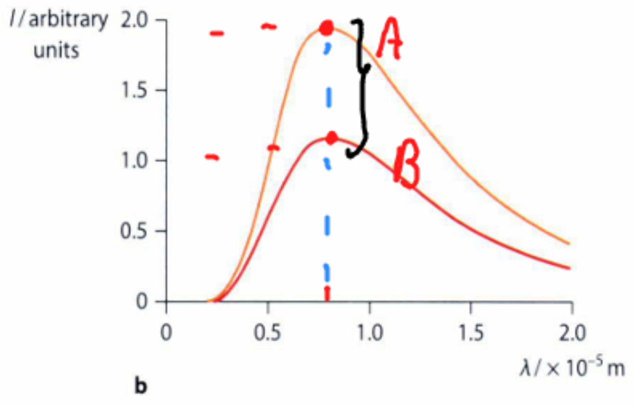


Figure 8.2: For question 1.

a Explain why the temperature of the two bodies is the same.

b The upper line corresponds to a black body. Calculate the emissivity of the other body.

2 The total power radiated by a surface of area 5.00 km^2 and emissivity 0.800 is 1.35 × 10^9 W. Assume that the surface radiates into a vacuum at temperature 0 K. Calculate the temperature of the surface.

3 A sphere of emissivity 0.80 has radius 0.50 m and temperature 27 °C. The temperature of the surroundings is 57 °C. At what rate does the body emit radiation and at what rate does it absorb radiation?

[redacted]

1) a) As we can see, the 2 bodies have the same peak wavelength, so according to wien's Law we can deduce that they have the same Temperature.

Furthermore, their graphs are similar - almost identical with the only exception being the peak of the curve which is due to a higher emissivity factor.

b) $e_A = 1$, since we are dealing with a black body.

$e_B = 0.5$ since it has, half the spectral intensity.

2) $\frac{P}{A} = e \cdot \sigma \cdot T^4 \Leftrightarrow$

$\frac{1.35 \cdot 10^9 \, W}{5 \cdot 10^6 \, m^2} = 0.8 \cdot 5.67 \cdot 10^{-8} \cdot T^4$ $W m^{-2} K^{-4}$

$T = \sqrt[4]{\frac{270 \cdot 10^{+8}}{0.8 \cdot 5.67}}$ K

$\boxed{T = 278 K}$ (5°C).

3) $e = 0.8$ / $r = 0.5$

$T_1 = 300K$ / $T_2 = 330$

$P = e \cdot \sigma \cdot A \cdot (T_2^4 - T_1^4)$, $A = 4\pi r^2$

$P = 0.8 \cdot 5.67 \cdot 10^{-8} \cdot 4\pi \cdot 0.25 \cdot (330^4 - 300^4)$

$P_{abs} = 536$ W (J/s) (absorbption)

$P_{emi} = e\sigma A \cdot (T_1^4 - T_2^4) = -536$ W.

$a \in (0,1)$
intensity
Energy Scattered: $(1-a)\cdot I$
(through radiation)
Incoming intensity: I
$\left(\frac{P}{A}\right)$
$I\cdot a$
(is the reflected)

a = albedo is basically a % of the amount of radiation a body receives

This disc area is πR^2. This energy is then spread over the whole of the sphere surface (day side and night side) which has a total area of $4\pi R^2$.

The average incident intensity $I_{surface}$ throughout the course of one day (24 h) at any point on the surface must be $\frac{\text{power arriving through the disc}}{\text{total surface area of Earth}} = \frac{S \times \pi R^2}{4\pi R^2} = \frac{S}{4}$.

Therefore $I_{surface} = \frac{1360}{4} = 340\,\mathrm{W\,m^{-2}}$ to 2 s.f.

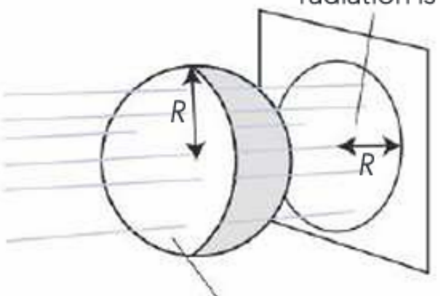
This is not the end of the story because we have neglected the effect of Earth's atmosphere. As the radiation from the Sun enters and travels through the atmosphere, it is subject to losses that reduce the energy arriving at the surface. Radiation is absorbed and scattered by the atmosphere. The degree to which this absorption and scattering occur depends on the position of the Sun in the sky at a particular place. When the Sun is lower in the sky (at dawn and sunset and near the poles), its radiation passes through a greater thickness of atmosphere and thus more scattering and absorption takes place. This also gives rise to the colours in the sky at dawn and dusk.

The energy arrives at ground level and is incident on the surface. The surface of Earth is not a black body and it scatters some energy back up towards the atmosphere. The extent to which a particular surface can scatter energy is known as its **albedo** (from the Latin word for "whiteness").

Albedo is given the symbol a:

$$a = \frac{\text{energy scattered by a given surface in a given time}}{\text{total energy incident on the surface in the same time}} = \frac{\text{total scattered power}}{\text{total incident power}}$$

Like emissivity, albedo is a ratio and has no units. It varies from 0 for a surface that scatters no energy (a black body) to 1 for a surface that absorbs no radiation at all. Unless stated otherwise, the albedo in Earth system is normally quoted for visible light.



▲ Figure 2 The radiation incident on half of Earth's sphere can be imagined as being incident on a circle with Earth's radius.

The inverse-square law used here is discussed in Topic B.1.

▲ Figure 3 Cloud cover affects the albedo of Earth.

By applying conservation of energy:

Incoming: I

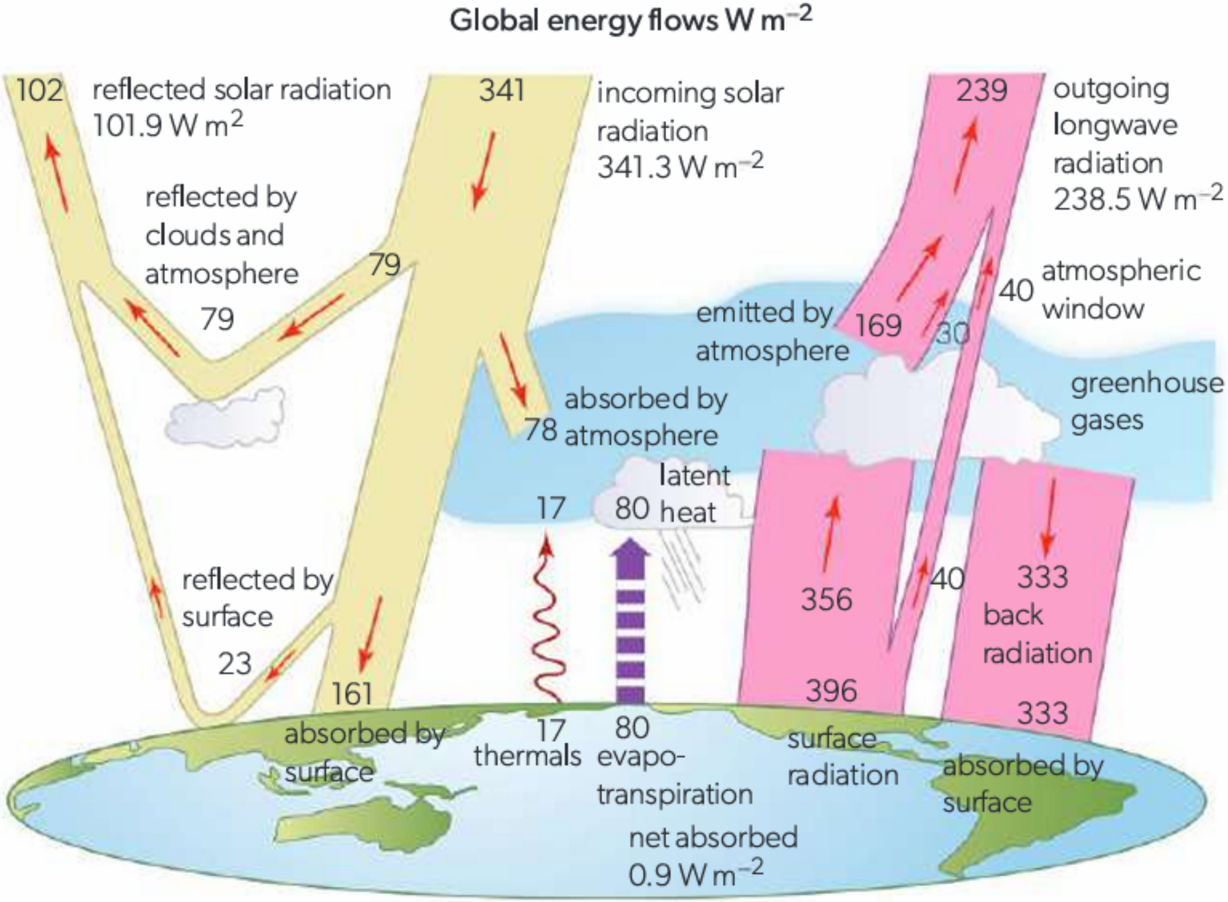
Repelled: $I_{reflected} + I_{rad}$

$= a\cdot I + (1-a)\cdot I$

$= \cancel{a\cdot I} + I - \cancel{a\cdot I} = I$

The energy balance of Earth

The surface–atmosphere energy balance system is very complex. Figure 15 is a diagram showing the basic interactions and you should study it carefully.



▲ Figure 15 The factors that make up the energy balance of Earth (after Stephens and others, 2012 An update on earth's energy balance in light of the latest global observations. *Nature Geoscience*.)

Global warming

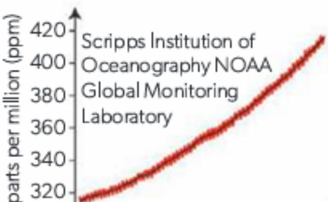
▲ Figure 16 Winter landscape with skaters (1608), Hendrick Avercamp.

There is no doubt that climate change is occurring on our planet. There is a significant warming that will ultimately lead to changes in sea level and climate across the world. The fact that there is change should not surprise us. We have recently (in geological terms) been through several Ice Ages and we are thought to be in an interstadial phase (between Ice Ages) now. In the 17th century, a "Little Ice Age" covered much of northern Europe and North America. The River Thames, in London, regularly froze, and the citizens held fairs on the ice. In 1608, the Dutch painter Hendrick Avercamp painted a winter landscape showing the typical extent and thickness of the ice in Holland (Figure 16).

Many models have been suggested to explain global warming, they include:

- changes in the composition of the atmosphere (and specifically the greenhouse gases) leading to an enhanced greenhouse effect
- increased solar flare activity
- cyclic changes in Earth's orbit
- volcanic activity.

Scientists now recognize that climate change is due to the burning of fossil fuels, which has gone on at increasing levels since the Industrial Revolution in the 18th century. There is much evidence for this. Table 3 shows some of the changes in the principal greenhouse gases over the past 250 years.



Gas	Pre-1750 concentration / ppb	Recent concentration / ppb	% increase since 1750
carbon dioxide	280 000	410 000	46
methane	700	1900	170
nitrous oxide	270	330	20

ppb = parts per billion

Intro to Gas Laws

$n = \frac{N}{N_A}$ molecules

Mr

$n = 6.02 \cdot 10^{23}$ Avogadro Constant.

$P = \frac{F}{A}$ $\frac{\text{force}}{\text{area}}$

scalar

$n = \frac{m}{Mr}$

molar mass.

$\left\{ \begin{array}{l} m = 28g \\ Mr_{H_2} = 2g\,mol^{-1} \end{array} \right\}$

$n = \frac{m}{Mr_{H_2}}$

$n_{H_2} = \frac{28g}{2g\,mol^{-1}}$

$\boxed{n_{H_2} = 14\,mol}$

$N = 14 \cdot 6.02 \cdot 10^{23}$

$N = 8.43 \cdot 10^{24}$ molecules of H_2

$\frac{PV}{T} = n \cdot R$ so $\frac{PV}{T}$ = constant

$PV = n \cdot R \cdot T = \frac{N}{N_A} R T =$

K_B

$PV = N K_B T$

(1) 1 mol of Ferraris = $6.02 \cdot 10^{23}$.

(3) $\boxed{Mr_S = 28g\,mol^{-1}}$

$n_S = \frac{m_S}{Mr_S}$

$n_S = \frac{12g}{28g\,mol^{-1}} = 0.43$ moles

(4) $\left. \begin{array}{l} m_{He} = 6g \\ Mr_{He} = 4g\,mol\,g^{-1} \end{array} \right\}$ $n_{He} = 1.5$ moles.

(5) $n = \frac{N}{N_A} = \frac{2 \cdot 10^{24}}{6.02 \cdot 10^{23}} = 3.3$ moles

(6) $\left. \begin{array}{l} Mr = 32g\,mol^{-1} \\ n = 3\,mol \end{array} \right\} \Rightarrow$ $m = n \cdot Mr = 96g$

9.2: The Ideal Gas

$$\frac{N}{N_A} = \frac{m_{He}}{Mr_{He}}$$

$$\frac{1}{6.02 \cdot 10^{23}} = \frac{m}{4} \Rightarrow \boxed{m = 6.64 \cdot 10^{-24}\ g}$$

Ideal Gas Assumptions (For the theoretical to be developed):

1) The molecules are point particles, each with negligible, therefore we ignore their geometry

2) The molecules obey the laws of mechanics (which means that we can apply to them all the conservation theorems)

3) The only forces present in the particles - molucules are during collisions (no attractive forces or any other type of shit)

$$1\ Pa \rightarrow 1\ \frac{N}{m^2} \xrightarrow{F = m \cdot a} 1\ \frac{kg \cdot \cancel{m} \cdot s^{-2}}{m^{\cancel{2}}} \rightarrow 1\ kg \cdot m^{-1} \cdot s^{-2}$$

4) The duration of a collision is negligible compared to the time between collisions

5) The collisions of the molecules with each other and with the container are elastic (which means that kinetic energy is conserved and we can apply energy theorems or conservation of momentum)

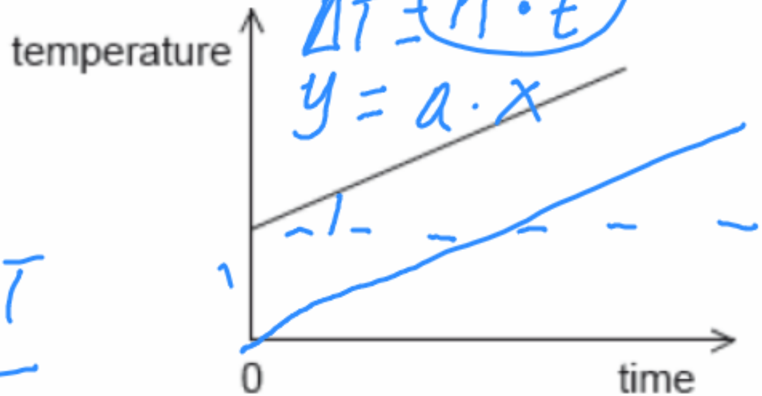
6) Molecules have a range of speeds and move randomly

4. *[1 mark]*

The graph shows how the temperature of a liquid varies with time when energy is supplied to the liquid at a constant rate P. The gradient of the graph is K and the liquid has a specific heat capacity c.

$\Delta T = K \cdot t$

$y = a \cdot x$



$Q = m c \Delta T$

$\frac{P}{t} = \frac{m c \Delta T}{t}$

What is the mass of the liquid?

A. $\frac{P}{cK}$

B. $\frac{PK}{c}$

C. $\frac{Pc}{K}$

D. $\frac{cK}{P}$

$P = \frac{m \cdot c \Delta T}{t}$

$\frac{P \cdot t}{c \cdot \Delta T} = m \Rightarrow m = \frac{P \cdot \cancel{t}}{c \cdot K \cdot \cancel{t}} = \frac{P}{c \cdot K}$

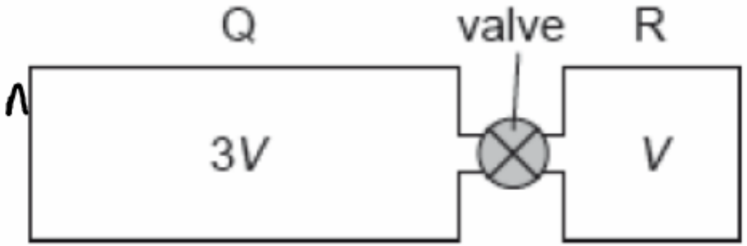
7. *[1 mark]*

Q and R are two rigid containers of volume $3V$ and V respectively containing molecules of the same ideal gas initially at the same temperature. The gas pressures in Q and R are p and $3p$ respectively. The containers are connected through a valve of negligible volume that is initially closed.

$\Delta P_Q = P_{Qf} - P_{Qin}$

$\Delta P_Q = P_{Qf} - p$

$\Delta P_Q = \frac{3p}{2} - p = +\frac{p}{2}$



$P_{Qf} = P_{Q+R} = \frac{3P_Q + P_R}{4}$

$P_{Qf} = \frac{3p + 3p}{4} = \frac{6p}{4} = \frac{3p}{2}$

The valve is opened in such a way that the temperature of the gases does not change. What is the change of pressure in Q?

A. $+p$

B. $\frac{+p}{2}$

C. $\frac{-p}{2}$

D. $-p$

$n_Q + n_R = n_{Q+R}$

$\cancel{RT}\,\frac{P_Q \cdot V_Q}{\cancel{RT}} + \cancel{RT}\,\frac{P_R \cdot V_R}{\cancel{RT}} = \cancel{RT}\,\frac{P_{Q+R} \cdot V_{Q+R}}{\cancel{RT}}$

$\frac{P_Q \cdot 3\cancel{V} + P_R \cdot \cancel{V}}{4} = \frac{P_{Q+R} \cdot 4 \cdot \cancel{V}}{4}$