You should try to answer on your own before seeking H-E-L-P-S. learning CORNER

# TOPIC opening ........

*Question 1*

An electric kettle, rated 230 V 8.0 A, contains some water. It is placed on a balance, as illustrated in Fig. 6.1.

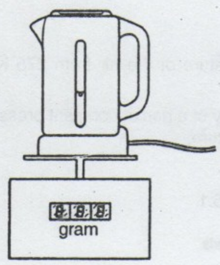


Fig. 6.1

The kettle is switched on and, when the water is boiling, the reading on the balance is found to decrease by 8.1 g in 10 s.

(a) Calculate

(i) the power rating of the kettle,

(ii) the specific latent heat of vaporisation of water. [4]

(b) (i) State one source of error in this determination of the specific latent heat of vaporisation.

(ii) Suggest briefly how this error may be reduced. [2]

[D99/P2/Q6]

## Suggested Solution:

(a) (i) Power rating of kettle, $P = IV$

$= (8.0)(230) = 1840$ W

(ii) Assuming that all of the heat produced by the kettle is expended through the vaporisation of water,

$$IVt = ml$$

$$l = \frac{IVt}{m} = \frac{(8.0)(230)(10)}{8.1 \times 10^{-3}} = 2.27 \times 10^{6}\ \text{J kg}^{-1}$$

(b) (i) The heat produced by the kettle that is transferred to the balance through conduction is not taken into account.

(ii) Lag the balance using fabrics that are poor conductors of heat to minimise the amount of heat being conducted to the balance.

(b) Alternative answer:

(i) The heat produced by the kettle that is transferred to the surrounding air through convection is not taken into account.

(ii) Lag the kettle by surrounding it with fabrics that are poor conductors of heat to minimise the amount of heat being transferred to the surrounding air through convection.

***Question 2***

**(a)** Define *specific heat capacity.* [2]

**(b)** Outline the principles involved in measuring the specific heat capacity of a liquid using an electrical method. [4]

**(c)** Write down a word equation relating the increase in the internal energy of a system to the amount of energy put in by heating and working on the system. [1]

**(d)** A hot air balloon contains 850 $m^3$ of air at an assumed constant temperature of 390 K. The density of the air at this temperature is 0.903 $kgm^{-3}$ and the specific heat capacity of the air under the conditions in which it is heated is 1000 $Jkg^{-1}K^{-1}$, calculate

(i) the mass m of air in the balloon at 390 K,

(ii) the heat energy required to raise the temperature of the air from 275 K to 390 K,

(iii) the density of air at 275 K, given that the density of a gas at constant pressure is inversely proportional to the Kelvin temperature,

(iv) the volume which mass $m$ occupies at 275 K. [8]

**(e)** The balloon referred to in **(d)** is illustrated in Fig. 5.1

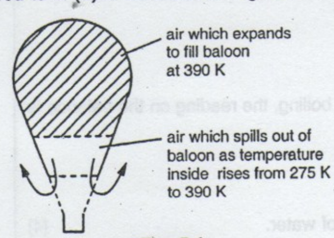


**Fig. 5.1**

The diagram shows that, during the heating process, air which was originally within the balloon spills out from the balloon. Calculate the work done on the atmosphere during this process. Atmospheric pressure is $1.03 \times 10^5$ Pa. [2]

**(f)** Apply the equation from **(c)**, together with your answers from **(d)(ii)** and **(e)**, to find the change in the internal energy of the mass m of air when heated from its initial temperature of 275 K to its final temperature of 390 K. [3]

*[D01/P3/Q5]*

***Suggested Solution:***

**(a)** *Specific heat capacity* refers to the amount of heat energy needed to raise the temperature of a given object by one kelvin, divided by the mass of the object.

**(b)** Water from a constant-head tank flows through a glass tube and is later collected as it flows out. The water is heated by a spiral resistance wire, which carries a steady electric current. The temperature, as the water enters and leaves, is measured by two thermometers. The apparatus is surrounded by a glass jacket, which is evacuated, so that heat cannot escape from the water by conduction or convection.

The mass of water $m$, which flows out of the tube in $t$ seconds, is measured. If the water enters at a temperature $\theta_1$ and leaves at $\theta_2$, then its mean specific heat capacity $c_w$ is given by

$$mc_w(\theta_2 - \theta_1) = IVt$$

$$c_w = \frac{IVt}{m(\theta_2 - \theta_1)}$$

(b) This is the method for determining specific heat capacity of a liquid by the continuous flow method, devised by Callendar and Barnes.

**(c)** The increase in the internal energy of a system
= Amount of energy put in by heating + Work done on the system

(d) (i) Density $= \frac{\text{Mass}}{\text{Volume}}$ $\Rightarrow$ Mass = Density × Volume

$= 0.903 \times 850 = 768$ kg

(ii) Heat energy required $= mc\theta$

$= 768 \times 1000 \times (390 - 275) = 8.83 \times 10^7$ J

(iii) If $\rho \propto \frac{1}{T}$, $\frac{\rho_1}{\rho_2} = \frac{T_2}{T_1}$

$\rho_1 = \frac{T_2}{T_1} \times \rho_2 = \frac{390}{275} \times 0.903 = 1.28$ kgm$^{-3}$

(iv) Volume $= \frac{\text{Mass}}{\text{Density}} = \frac{768}{1.28} = 600$ m$^3$

(e) Increase in volume of the air when it expands as temperature rises from 275 K to 390 K = 850 − 600 = 250 m³.

Work done on the atmosphere $= p\Delta V$

$= (1.03 \times 10^5) \times 250 = 2.58 \times 10^7$ J

(f) Increase in internal energy of the air $= 8.83 \times 10^7 - 2.58 \times 10^7 = 6.25 \times 10^7$ J

***Question 3***

Some gas is contained in a cylinder by means of a moveable piston, as illustrated in Fig. 5.1.

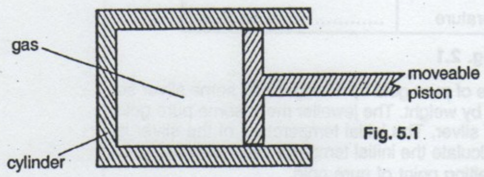


Fig. 5.1

State how, for this mass of gas, the following changes may be achieved.

(a) increase its gravitational potential energy. [1]

(b) decrease its internal energy. [1]

(c) increase its elastic potential energy [1]

*[J02/P2/Q5]*

***Suggested Solution:***

(a) Raise the height of the cylinder above the earth.

(b) Reduce the temperature of the mass of gas by moving the piston to the right so that the volume of the gas increases, leading to a decrease in the root-mean-square speed of the gas molecules.

(c) Push the moveable piston to the left to increase the pressure of the gas through compression of the gas.

(a) P.E = $mgh$

Reducing $h$ would reduce P.E.

(b) Internal energy ∝ temperature for an ideal gas.

***Question 4***

Some water in a saucepan is boiling.

(a) Explain why

(i) external work is done by the boiling water,

(ii) there is a change in the internal energy as water changes to steam. [5]

(b) By reference to the first law of thermodynamics and your answers in (a), show that thermal energy must be supplied to the water during the boiling process. [2]

*[J02/P4/Q2]*

**Suggested Solution:**

(a) (i) As the water boils, water molecules leave the water surface and enter the surrounding air. In so doing, the boiling water has done external work on the atmosphere surrounding the water.

(ii) The internal energy of the water is the sum of the random distribution of kinetic and potential energies associated with the water molecules. As water changes to steam, the separations of the water molecules increase and the potential energies increase, leading to an increase in the internal energy.

(b) According to the First Law of Thermodynamics, an increase in the internal energy, $\Delta U$ of a system equals the heat supplied to the system, $Q$ and the work done on the system, $W$.

$$\Delta U = \Delta Q + \Delta W$$

During boiling, work is done by the boiling water. Hence, in order for the internal energy to increase, heat must be supplied to the water during the boiling process to supply required energy to do work against the surroundings.

***Question 5***

(a) On Fig. 2.1, place a tick (✓) against those changes where the internal energy of the body is increasing. [2]

| | |
|---|---|
| water freezing at constant temperature | .............................. |
| a stone falling under gravity in a vacuum | .............................. |
| water evaporating at constant temperature | .............................. |
| stretching a wire at constant temperature | .............................. |

**Fig. 2.1**

(b) A jeweller wishes to harden a sample of pure gold by mixing it with some silver so that the mixture contains 5.0% silver by weight. The jeweller melts some pure gold and then adds the correct weight of silver. The initial temperature of the silver is 27 °C. Use the data of Fig. 2.2 to calculate the initial temperature of the pure gold so that the final mixture is at the melting point of pure gold.

| | gold | silver |
|---|---|---|
| melting point / K | 1340 | 1240 |
| specific heat capacity (solid or liquid) / J $kg^{-1}$ $K^{-1}$ | 129 | 235 |
| specific latent heat of fusion / kJ $kg^{-1}$ | 628 | 105 |

**Fig. 2.2**

(c) Suggest a suitable thermometer for the measurement of the initial temperature of the gold in (b). [1]

*[J03/P4/Q2]*

**Suggested Solution:**

(a)

| | |
|---|---|
| water freezing at constant temperature | .............................. |
| a stone falling under gravity in a vacuum | .............................. |
| water evaporating at constant temperature | ..........✓.................... |
| stretching a wire at constant temperature | ..........✓.................... |

(a) Since, $\Delta U = \Delta E_K + \Delta E_P$

$\Delta E_K$ = Constant due to constant temperature.

$\Delta E_P$ = Increases due to breaking of bonds and increase in the separation between particles. So internal energy ($\Delta U$) increases.

**(b)** By conservation of energy and assuming that no heat is lost to the surroundings,

Heat lost by the gold = Heat gained by the silver when the gold and silver is mixed

$$\Rightarrow \quad m_1 c_1 \Delta\theta_1 = m_2 c_2 \Delta\theta_2$$

$$\Rightarrow \quad \left(\frac{95}{100} \times M\right) \times 129 \times (T_1 - 1340) = \left(\frac{5}{100} \times M\right) \times 235 \times (1340 - (27 + 273.15))$$

Where $M$ is the total mass of gold and silver mixed and $T_1$ is the initial temperature of the pure gold.

$$T_1 = 1340 + \frac{5}{95} \times \frac{235}{129} \times (1340 - 300.15) = 1440 \text{ K}$$

**(c)** The radiation pyrometer.

**(c)** The radiation pyrometer can be used to measure temperature beyond 1250 K.

***Question 6***

A student sets up the apparatus illustrated in Fig. 2.1 in order to determine a value for the specific latent heat of fusion of ice.

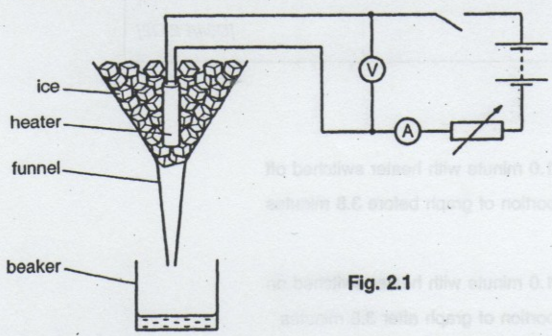


**Fig. 2.1**

A heater is placed in the funnel, surrounded by pure melting ice. The student measures the mass of melted ice in the beaker at regular time intervals before and after switching on the heater. The variation with time $t$ of the mass $m$ of melted ice in the beaker is shown in Fig. 2.2.

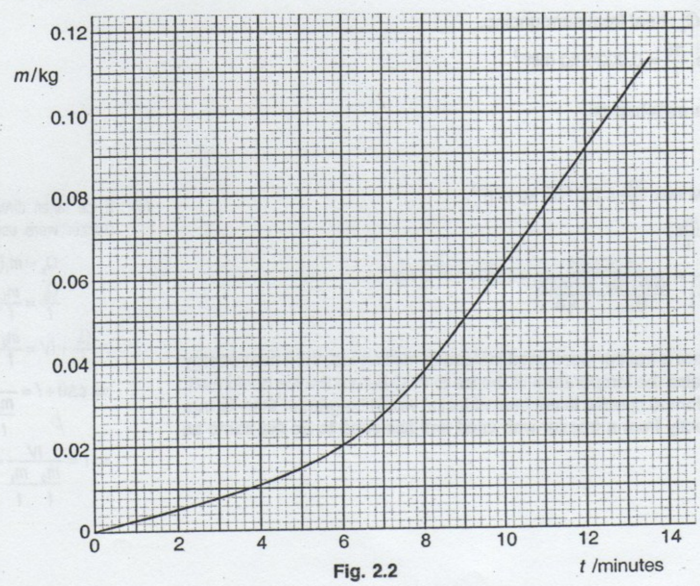


**Fig. 2.2**

During the heating process, the current is adjusted so that the readings on the ammeter and voltmeter are constant.

**(a)** By reference to Fig. 2.2,

**(i)** suggest a time at which the heater is switched on,

time = ........................ minutes [1]

**(ii)** determine the mass of ice melted in 1.0 minute

**1.** with the heater switched off,

**2.** with the heater switched on. [2]

**(b)** The readings of the ammeter and the voltmeter are 5.2 A and 11.5 V respectively. Use your answers in (a) to calculate a value for the specific latent heat of fusion of ice.

specific latent heat of fusion = ........................ J kg$^{-1}$ [3]

**(c)** State and explain the effect on your calculated value for the specific latent heat of fusion if ice taken directly from a freezer were used to replace the ice in the funnel. [2]

*[D04/P2/Q2]*

***Suggested Solution:***

**(a) (i)** Time = 3.8 minutes

**(ii) 1.** Mass of ice melted in 1.0 minute with heater switched off

= Gradient of straight portion of graph before 3.8 minutes

$= \frac{0.01}{3.8} = 0.0026$ kg

**2.** Mass of ice melted in 1.0 minute with heater switched on

= Gradient of straight portion of graph after 3.8 minutes

$= \frac{0.108 - 0.064}{13.2 - 10.0} = 0.0138$ kg

**(b)** When the heater was switched off,

$Q_s = m_1 l$ where $Q_s$ : heat from surrounding.

$\frac{Q_s}{t} = \frac{m_1}{t} l$ where $\frac{m_1}{t} = 0.0026$ kg min$^{-1}$.

When the heater was switched on,

$Q_s + IVt = m_2 l$

$\frac{Q_s}{t} + IV = \frac{m_2}{t} l$ where $\frac{m_2}{t} = 0.0138$ kg min$^{-1}$.

$\Rightarrow \frac{m_1}{t} l + IV = \frac{m_2}{t} l$

$\Rightarrow l = \frac{IV}{\left(\frac{m_2}{t} - \frac{m_1}{t}\right)} = \frac{5.2 \times 11.5}{\frac{0.0138}{60} - \frac{0.0026}{60}} = 3.20 \times 10^5$ J kg$^{-1}$

**(c)** If ice taken directly from a freezer were used instead of melting ice, then heat energy would be needed to raise the temperature of the ice to 0 °C before the ice could melt. The calculated value for the specific latent heat of fusion would be greater than its true value if ice taken directly from a freezer was used and assumed to be the same as melting ice.

(c) If ice taken directly from a freezer were used,

$Q_s = m_1(c\Delta\theta + l)$

$\frac{Q_s}{t} = \frac{m_1}{t}(c\Delta\theta + l)$

$\therefore \frac{Q_s}{t} + IV = \frac{m_2}{t}(c\Delta\theta + l)$

$\Rightarrow c\Delta\theta + l = \frac{IV}{\frac{m_2}{t} - \frac{m_1}{t}}$

$\Rightarrow l = \frac{IV}{\frac{m_2}{t} - \frac{m_1}{t}} - c\Delta\theta$

*Question 7*

**(a)** In a space, such as a swimming pool enclosure, water at 30 °C and water vapour, also at 30 °C, coexist.

**(i)** Compare the pattern of movement and the speed of molecules in water and water vapour at the same temperature. [4]

**(ii)** State what is meant by the *internal energy* of a system. [2]

**(iii)** Using your answer to **(ii)**, compare the internal energy per unit mass of water and water vapour at the same temperature. [3]

**(iv)** Explain, in terms of internal energy, why the specific latent heat of vaporisation of a substance is greater than its specific latent heat of fusion. [2]

**(b)** A canal connects a reservoir to a town. The canal supplies the town with fresh water. During a summer month, the town is supplied with water at an average rate of 2.7 $m^3 s^{-1}$. The canal is 51 km long and 9.2 m wide. In the daytime, the average power from the Sun that is absorbed per unit area by the surface of the water is 900 W $m^{-2}$. The temperature of the water does not change.

**(i)** Explain why more water needs to be supplied from the reservoir than is used by the town. [1]

**(ii)** The density of water is 1000 kg $m^{-3}$ and the specific latent heat of vaporisation of water is $2.26 \times 10^6$ J $kg^{-1}$. Calculate the rate at which water needs to be supplied from the reservoir. [4]

**(iii)** Suggest **two** ways in which the loss of water from the canal could be reduced. Indicate the problems that could arise if your suggestions were to be implemented. [4]

*[N06/P3/Q2]*

***Suggested Solution:***

**(a) (i)**

| | pattern of movement | speed of molecules |
|---|---|---|
| water | random | slow |
| water vapour | random | fast |

**(ii)** Internal energy of a system is determined by the state of the system and can be expressed as the sum of a random distribution of kinetic and potential energies of particles of matter.

**(iii)** The Internal energy of water vapour is higher than water due to greater potential energy of water vapours because of greater spacing between their particles.

(a) (iii) Kinetic energy of water and water vapours is same due to constant temperature.

**(iv)** Specific latent heat of vaporisation is greater because of overcoming a greater intermolecular potential energies compared to specific latent heat of fusion. The kinetic energies remains unchanged during respective change of state.

**(b) (i)** Some water is evaporated to keep the temperature constant.

**(ii)** Rate of energy supplied by Sun = Rate of water evaporating

$$(900\ Wm^{-2})(51\times10^3)(9.2) = x(2.26\times10^6)$$

$$x = 190\ kgs^{-1}$$

**(iii)**

| Solution | Problem |
|---|---|
| 1. Cover the canal | Aesthetically unpleasant and possibly expensive |
| 2. Increase rate of flow of water | Construction to steepen the gradient will be expensive |

***Question 8***

**(a)** Use the kinetic theory of matter to explain why melting requires energy but there is no change in temperature. [3]

**(b)** Define *specific latent heat of fusion*. [2]

**(c)** A block of ice at 0°C has a hollow in its top surface, as illustrated in Fig. 2.1.

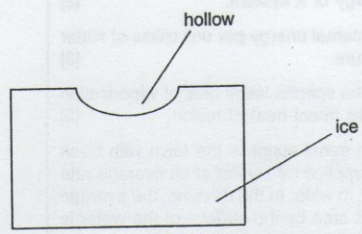


**Fig. 2.1**

A mass of 160 g of water at 100 °C is poured into the hollow. The water has specific heat capacity 4.20 kJ kg$^{-1}$ K$^{-1}$. Some of the ice melts and the final mass of water in the hollow is 365 g.

**(i)** Assuming no heat gain from the atmosphere, calculate a value, in kJkg$^{-1}$, for the specific latent heat of fusion of ice. [3]

**(ii)** In practice, heat is gained from the atmosphere during the experiment. This means that your answer to **(i)** is not the correct value for the specific latent heat. State and explain whether your value in **(i)** is greater or smaller than the correct value. [2]

*[J07/P4/Q2]*

***Suggested Solution:***

**(a)** During melting, bonds between molecules are weakened and move further apart. There is no change in kinetic energy as temperature is constant while potential energy increases as molecules move apart, so energy is required.

**(b)** Amount of heat required to convert unit mass of a solid to liquid state with no change in temperature / at its normal boiling point.

(b) Do not use 1 kg mass because units are not used to define a physical quantity.

**(c) (i)** Energy lost by hot water = Energy absorbed to melt ice

$$(\text{mass of water})c(\theta_2-\theta_1)=(\text{mass of melted ice})l$$

$$(160\times10^{-3})(4.20\times10^3)(100-0)=\left[(365-160)\times10^{-3}\right]l$$

$$l=327.8\times10^3$$

$\therefore$ specific latent heat = 328 kJkg$^{-1}$

(c) In $Q = ml$, mass of changed state of matter is considered.

**(ii)** Smaller value because ice would also be melted by the heat gained from atmosphere, resulting in an increased mass and reduced value for specific latent heat.

### *Question 9*

A spring is placed on a flat surface and different weights are placed on it, as shown in Fig. 2.1.

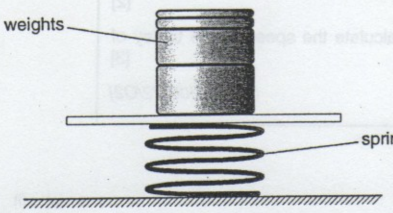


Fig. 2.1

The variation with weight of the compression of the spring is shown in Fig. 2.2.

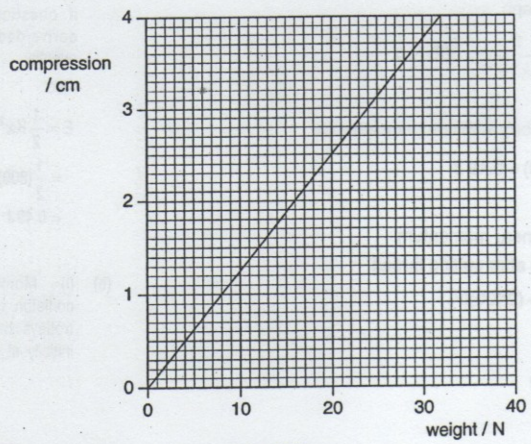


Fig. 2.2

The elastic limit of the spring has not been exceeded.

**(a)** **(i)** Determine the spring constant $k$ of the spring. [2]

**(ii)** Deduce that the strain energy stored in the spring is 0.49 J for a compression of 3.5 cm. [2]

**(b)** Two trolleys, of masses 800 g and 2400 g, are free to move on a horizontal table. The spring in **(a)** is placed between the trolleys and the trolleys are tied together using thread so that the compression of the spring is 3.5 cm, as shown in Fig. 2.3.

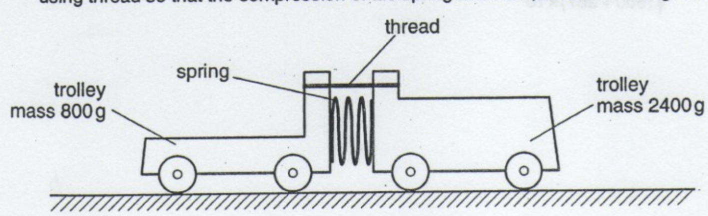


Fig. 2.3

Initially, the trolleys are not moving.
The thread is then cut and the trolleys move apart.

(i) Deduce that the ratio

$$\frac{\text{speed of trolley of mass 800 g}}{\text{speed of trolley of mass 2400 g}}$$

is equal to 3.0. [2]

(ii) Use the answers in **(a)(ii)** and **(b)(i)** to calculate the speed of the trolley of mass 800 g. [3]

*[J08/P2/Q2]*

***Suggested Solution:***

**(a) (i)** Gradient $= \frac{4.0 \times 10^{-2} - 0}{32 - 0} = 1.25 \times 10^{-3}$

Spring constant = Reciprocal of gradient of compression / cm against weight / N graph.

$$\Rightarrow \quad K = \frac{1}{\text{gradient}} = \frac{1}{1.2 \times 10^{-3}} = 800 \text{ Nm}^{-1}$$

**(ii)** Strain energy = Area of graph along with compression axis

$$= \frac{1}{2}(3.5 \times 10^{-2})(28) = 0.49 \text{ J}$$

**(b) (i)** By principle of conservation of linear momentum

Momentum before = Momentum after cutting thread

$$O = (800)(-v_1) + (2400)(v_2)$$

$$800\, v_1 = 2400 v_2$$

$$\frac{v_1}{v_2} = \frac{2400}{800} = 3.0$$

**(ii)** energy stored in spring = kinetic energy of trolleys

$$0.49 = \frac{1}{2}(800 \times 10^{-3})(v_1)^2 + \frac{1}{2}(2400 \times 10^{-3})(v_2)^2$$

$$0.98 = (800 \times 10^{-3})(v_1)^2 + (2400 \times 10^{-3})(\frac{v_1}{3})^2$$

$$0.98 = (800 \times 10^{-3})v_1^2 + (267 \times 10^{-3})v_1^2$$

$$v_1 = \sqrt{\frac{0.98}{(800 + 267) \times 10^{-3}}} = 0.958 \approx 0.96 \text{ ms}^{-1}$$

(a) (i) Do not forget to change compression from cm into metre (m).

(ii) Full explanation is vital if question is asked to derive/deduce a given quantity.

Also

$$E = \frac{1}{2}Kx^2$$

$$= \frac{1}{2}(800)(3.5 \times 10^{-2})$$

$$= 0.49 \text{ J}$$

(b) (i) Momentum before collision is zero for both trolleys because they are initially at rest.

(b) (ii) By principle of conservation of energy, strain energy of the spring is equal to the sum of kinetic energies of both trolleys.

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*Question 10*

(a) Define *specific latent heat of fusion.* [2]

(b) Some crushed ice at 0 °C is placed in a funnel together with an electric heater, as shown in Fig. 2.1.

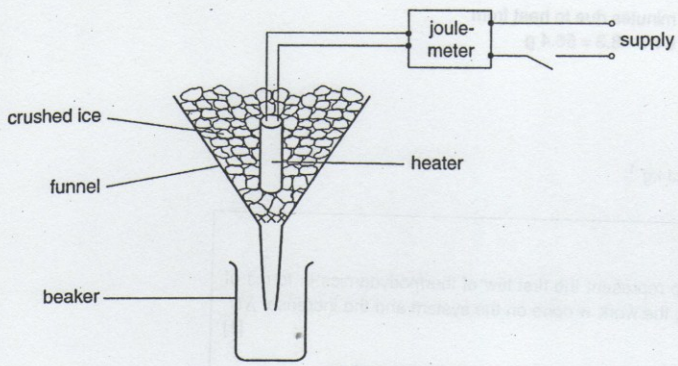


Fig 2.1

The mass of water collected in the beaker in a measured interval of time is determined with the heater switched off. The mass is then found with the heater switched on. The energy supplied to the heater is also measured.

For both measurements of the mass, water is not collected until melting occurs at a constant rate.

The data shown in Fig. 2.2 are obtained.

| | Mass of water / g | Energy supplied to heater / J | Time interval / min |
|---|---|---|---|
| Heater switched off | 16.6 | 0 | 10.0 |
| Heater switched on | 64.7 | 18000 | 5.0 |

Fig 2.2

(i) State why the mass of water is determined with the heater switched off. [1]

(ii) Suggest how it can be determined that the ice is melting at a constant rate. [1]

(iii) Calculate a value for the specific latent heat of fusion of ice. [3]

*[N08/P4/Q2]*

***Suggested Solution:***

(a) Amount of heat required to convert unit mass of a solid to liquid state at it's normal melting point or at constant temperature.

(a) Units are not used to define a physical quantity i.e. do not use 1kg of mass in the definition.

(b) (i) To check that how much mass of ice is melted by absorbing energy from the surrounding.

(ii) By checking that constant change of mass of water collected per equal time interval in the beaker.

**(iii)** Mass of ice melted in 5 minutes due to heat from surrounding $= m_1 = \frac{16.6}{2} = 8.3\text{g}$

Mass of ice melted in 5 minutes due to heat from surrounding as well as from heater $= m_2 = 64.7\text{g}$

Mass of ice melted in 5 minutes due to heat from heater, $m = m_2 - m_1 = 64.7 - 8.3 = 56.4$ g

$Q = ml$

$18000 = (56.4 \times 10^{-3})l$

$l = 319 \times 10^3$

$\therefore$ latent heat $= 319$ kJ kg$^{-1}$

***Question 11***

**(a)** Write down an equation to represent the first law of thermodynamics in terms of the heating $q$ of a system, the work $w$ done on the system and the increase $\Delta U$ in the internal energy. [1]

**(b)** The pressure of an ideal gas is decreased at constant temperature. Explain what change, if any, occurs in the internal energy of the gas. [3]

*[N08/P4/Q4]*

***Suggested Solution:***

**(a)** $\Delta U = q + w$

**(b)** Potential energy of particles of an ideal gas is zero because of no intermolecular forces and Kinetic energy is also constant due to constant temperature. So there is no change in internal energy as $\Delta U = \Delta E_k + \Delta E_p$.

(a) Increase in the internal energy of the system is equal to the heat supplied to the system and work done on the system.

(b) Internal energy of an ideal gas is just the Kinetic energy of the particles and Kinetic energy is directly proportional to thermodynamic temperature.

***Question 12***

When a liquid is boiling, thermal energy must be supplied in order to maintain a constant temperature.

**(a)** State two processes for which thermal energy is required during boiling. [2]

**(b)** A student carries out an experiment to determine the specific latent heat of vaporisation of a liquid.

Some liquid in a beaker is heated electrically as shown in Fig. 3.1.

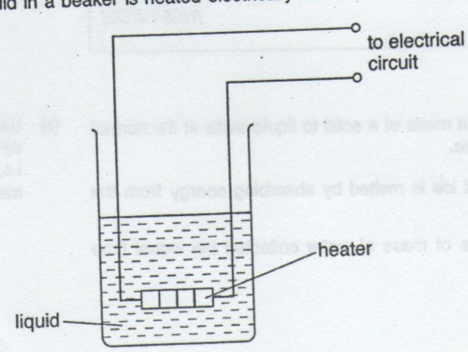


**Fig. 3.1**

Energy is supplied at a constant rate to the heater. When the liquid is boiling at a constant rate, the mass of liquid evaporated in 5.0 minutes is measured.

The power of the heater is then changed and the procedure is repeated. Data for the two power ratings are given in Fig. 3.2.

| power of heater / W | mass evaporated in 5.0 minutes / g |
|---|---|
| 50.0 | 6.5 |
| 70.0 | 13.6 |

**Fig. 3.2**

(i) Suggest

1. how it may be checked that the liquid is boiling at a constant rate, [1]
2. why the rate of evaporation is determined for two different power ratings. [1]

(ii) Calculate the specific latent heat of vaporisation of the liquid. [3]

*[J09/P4/Q3]*

***Suggested Solution:***

(a) 1. Thermal energy is used to break the bonds between molecules and to increase the separation between them.

2. Thermal energy is also needed to do work against atmospheric pressure during expansion.

(b) (i) 1. There is a constant decrease in the mass of water per unit time.

2. To eliminate the heat lost to the surrounding (atmosphere)

(ii) $\Delta Q = (\Delta m) l_v$

$\Rightarrow \quad (P_2 - P_1)t = (m_2 - m_1) l_v$

$\Rightarrow \quad (70.0 - 50.0)(5.0 \times 60) = (13.6 - 6.5) l_v$

$\Rightarrow \quad l_v = \dfrac{6000}{7.1} = 845$

$\therefore \quad$ specific latent heat of vaporisation $= 845\ \text{J g}^{-1}$

***Question 13***

(a) State what is meant by the *internal energy* of a gas. [2]

(b) The first law of thermodynamics may be represented by the equation

$$\Delta U = q + w.$$

State what is meant by each of the following symbols.

$+\Delta U$

$+q$

$+w$ [3]

(c) An amount of 0.18 mol of an ideal gas is held in an insulated cylinder fitted with a piston, as shown in Fig. 2.1.

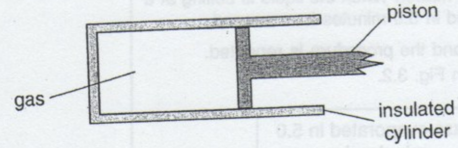


**Fig. 2.1**

Atmospheric pressure is $1.0 \times 10^5$ Pa.

The volume of the gas is suddenly increased from $1.8 \times 10^3$ cm³ to $2.1 \times 10^3$ cm³.

For the expansion of the gas,

calculate the work done by the gas and hence show that the internal energy changes by 30 J, [3]

*[N09/P42/Q2]*

***Suggested Solution:***

**(a)** It is the microscopic sum of random kinetic energy and potential energy of the particles of gas.

**(b)** $+\Delta U$ : Increase in internal energy

$+q$ : Heat supplied to the system

$+w$ : Work done on the system

**(c)** $w = p\Delta V$

$= (1.0\times10^5)(2.1\times10^3 - 1.8\times10^3)(10^{-2})^3 = 30 \text{ J}$

Since $q = 0$ and $\Delta w = 30$ J

so, $\Delta U = \Delta w = 30$ J