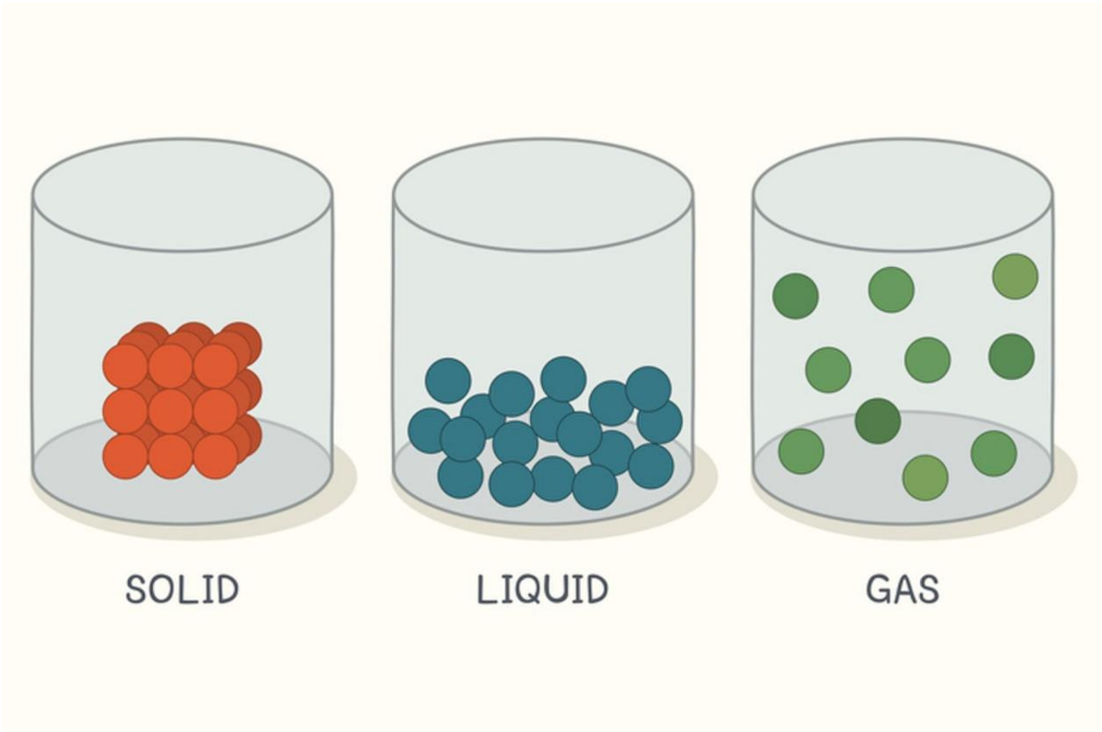
Grove Academy

National 5 Physics

Area: Properties of Matter

Problems



Section 1 – Specific Heat Capacity

Heat Transfer

1. Describe how heat travels through a material by:
   (a) Conduction.
   (b) Convection.
   (c) Radiation.
2. Explain why a cup of coffee with a temperature of 80 °C causes more damage when in contact with human skin than a spark from a sparkler with a temperature of 1600 °C.
3. Explain why a tomato feels warmer than melted cheese in a hot cheese and tomato toastie.
4. Describe, by referring to heat transfer by conduction, convection and radiation, how the clothing of a fire fighter is designed to help them do their job.
5. Describe how a central heating boiler can be made more efficient by stopping heat transfer by conduction, convection and radiation.

Heat and Temperature

6. State the difference between heat and temperature.
7. State what is meant by the following statement:
   "The specific heat capacity of water is 4180 $J kg^{-1}$ $°C^{-1}$."
8. Calculate the missing quantity from each row in the following table. Show all of your working.

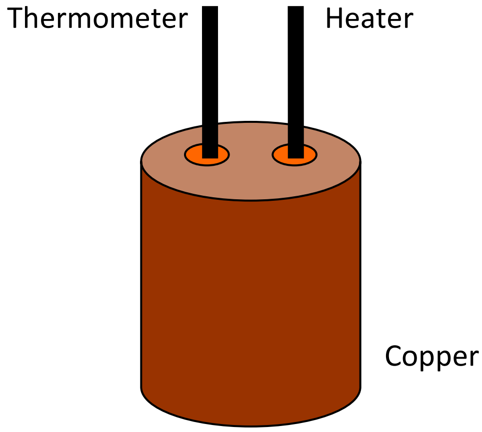
	Heat energy J	Specific Heat Capacity J kg^{-1} $°C^{-1}$	Mass kg	Change in Temperature °C
(a)		2350	2·0	10
(b)		902	5·0	25
(c)	36 900		4·5	2
(d)	6885		0·75	34
(e)	10 080	2100		12
(f)	105 600	480		40
(g)	2400	128	2·5	
(h)	27 690	2130	3·25	

9. Calculate how much heat energy is required to heat 3.0 kg of water from 20 °C to 80 °C.
10. A 2.4 kg lump of brass is heated up by a Bunsen burner. When 9120 J of heat energy has been absorbed, the temperature of the brass increases by 10 °C.
    Calculate the specific heat capacity of the brass.

11. A pane of glass has a mass of 800 g.
Calculate the temperature change of the glass if it is heated by 1000 J of heat energy.

12. A block of lead is heated from 24 $^\circ$C to 28 $^\circ$C by a heat source that gives off 6144 J of heat energy.
Calculate the mass of the lead block.

13. In an experiment, a 2 kg block of copper is warmed with a 70 W electrical immersion heater. The temperature of the copper is measured every minute using a thermometer. The heat energy used is calculated by finding the power of the heater and using $P = \frac{E}{t}$.
The results are shown below.



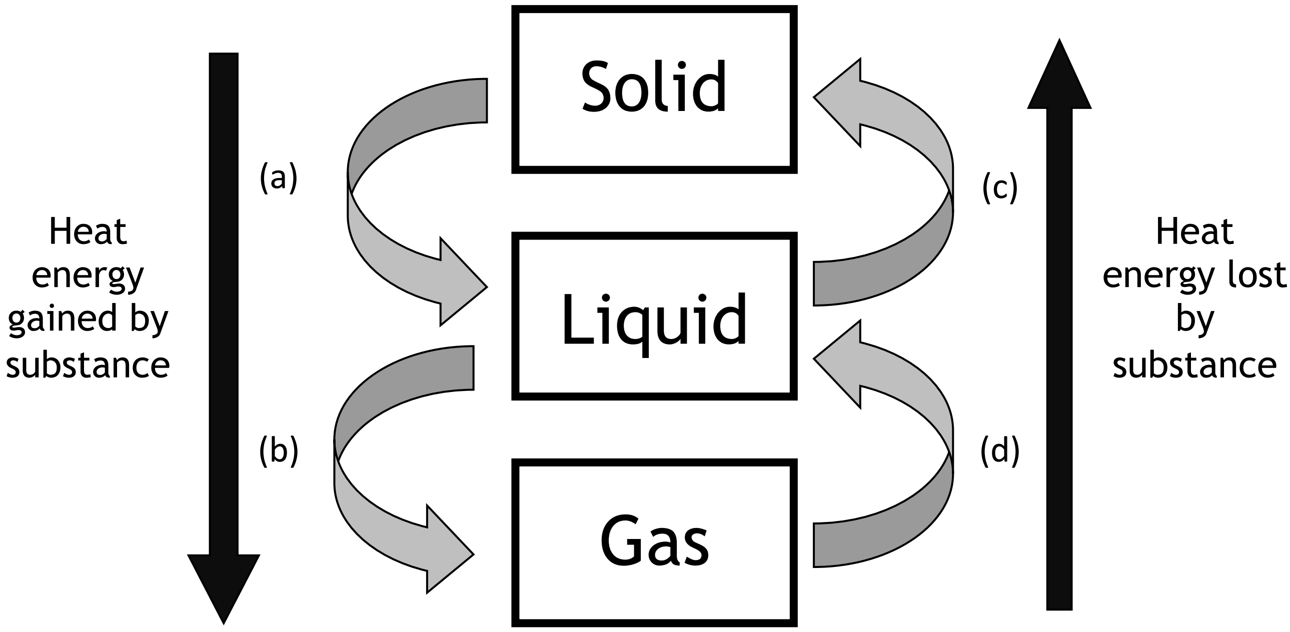
Heat energy J	**Temperature Change °C**
0	0
4 200	3·4
8 400	6·8
12 600	10·2
16 800	13·6
21 000	17·0

(a) Using *this data*, draw a line graph and use the gradient of the straight line to calculate the specific heat capacity of copper.
(b) State whether this experimental value for the specific heat capacity of copper is larger, smaller or the same as the actual value. Explain any difference.

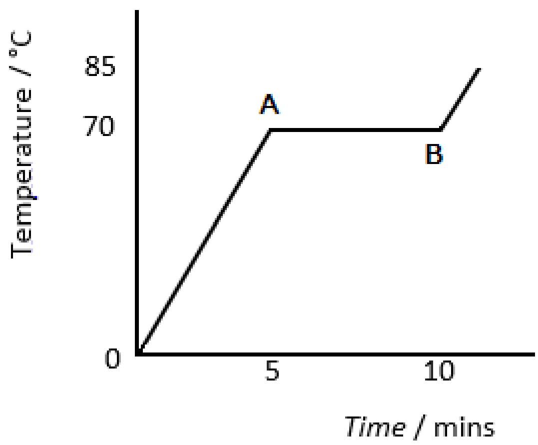
Section 2 – Specific Latent Heat

1. State what is meant by the following terms:
   (a) Specific Latent Heat of Vaporisation;
   (b) Specific Latent Heat of Fusion.

2. Identify the name of each change of state, labelled (a) to (d) in the following diagram.



3. Stearic acid is a solid at room temperature. 100 g of stearic acid is heated in a water bath until it reaches a temperature of 85 °C. The graph below shows how the temperature changes with time.



Describe and explain what happens to the stearic acid between points A and B.

4. Calculate the missing quantity from each row in the following table. Show all of your working.

	Heat energy J	Mass kg	Specific Latent Heat of Fusion J kg^{-1}
(a)		1·5	$0{\cdot}99 \times 10^5$
(b)		0·6	$3{\cdot}95 \times 10^5$
(c)	144 000		$1{\cdot}80 \times 10^5$
(d)	266 500		$2{\cdot}05 \times 10^5$
(e)	60 000	2·4	
(f)	48 060	0·18	

5. Determine how much heat energy is required to:
   (a) Turn 400 g of ice into 400 g of water;
   (b) Turn 400 g of water into 400 g of steam.

6. Determine how much heat energy is given out by:
   (a) 400 g of steam turning into 400 g of water;
   (b) 400g of water turning into 400 g of ice.

7. Calculate the mass of alcohol which required 1.008 MJ of energy to change all of the alcohol from a liquid to a gas.

8. A 50 g substance is a gas at room temperature. It is cooled to a very low temperature and it becomes 50 g of liquid. The substance releases 18 850 J of heat energy as it changes state.
   (a) Calculate the specific latent heat of vaporisation of the substance.
   (b) State the name of the substance.

9. In a laboratory, 150 g of water is found to have a temperature of 20 °C. It is heated to a temperature of 100 °C and it is all converted into steam. Calculate how much heat energy is required to convert 150 g of water at 20 °C into 150 g of steam at 100 °C.

Section 3 – Gas Laws and the Kinetic Model

Pressure

1. State the meaning of the term 'pressure' in terms of force and area.

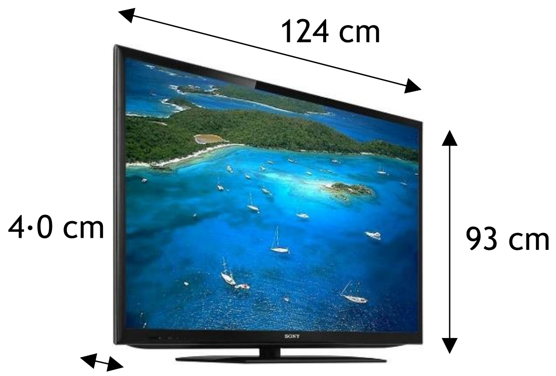
2. Calculate the missing quantity from each row in the following table. Show all of your working.

	Pressure Pa	Force N	Area m^2
(a)		120	1·6
(b)		4000	0·5
(c)	$1·1 \times 10^5$		2·0
(d)	9000		$8·0 \times 10^{-2}$
(e)	12 000	$7·2 \times 10^5$	
(f)	$1·4 \times 10^4$	$4·9 \times 10^4$	

3. A 480 g tin of baked beans is a cylinder with a radius of 3·2 cm. It is placed on a kitchen counter. Calculate the pressure on the counter caused by the tin.

4. A car of mass 1250 kg is driven onto a bridge. The pressure on the surface of the bridge when all four tyres are on the ground is 39·0 kPa. Calculate the contact area between *one* tyre and the bridge.

5. A television has a length of 124 cm, a height of 93 cm and a depth of 4·0 cm.



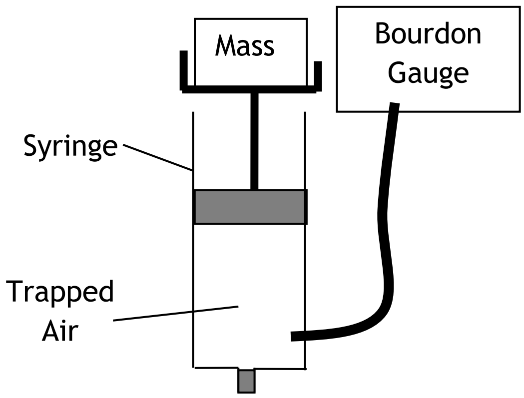
The television has a mass of 8·5 kg. Calculate the:

a) Maximum pressure that the television can exert on a surface;
b) Minimum pressure that the television can exert on a surface.

6. By measuring your weight and the area of your feet, calculate the pressure that you exert on the floor when:
a) You are standing normally.
b) You are standing on one foot.

7. State whether you are more likely to fall through an icy lake if you are on your tip toes or lying flat on your back with your arms and legs stretched out. Explain your answer.

8. In an experiment, a mass which has a weight of 1 N is placed on top of a syringe filled with trapped air. A Bourdon Gauge is used to measure the air pressure inside the syringe. This is then repeated for different masses. The results are given in the table below.



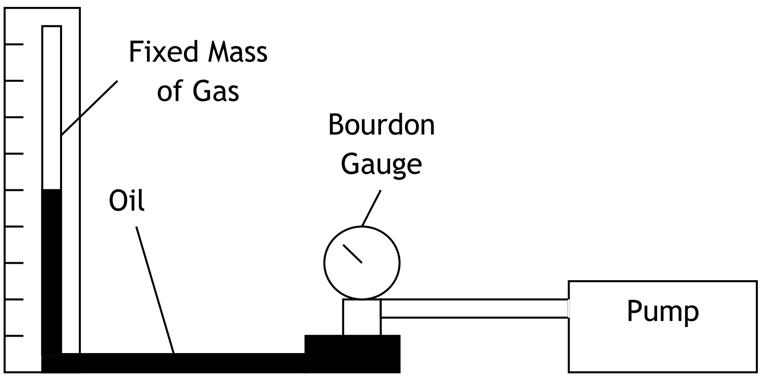
Force / N	Pressure / x 10^5 Pa
0	1·01
1	1·03
2	1·05
3	1·07
4	1·09
5	1·11

Use this data to construct a line graph of force against pressure, and use the gradient of the straight line to calculate the surface area of the syringe plunger inside the syringe.

9. Atmospheric pressure is 1·0 x 10^5 Pa, calculate the force that air exerts on a wall which has an area of 10 m^2.

Boyles' Law

10. In an experiment, the volume of a fixed mass of gas is decreased by trapping the gas at the top of a glass tube with a quantity of oil and then using a pump to push the oil up the tube. The pressure of the gas is measured with a Bourdon gauge and the volume of gas is measured using a calibrated scale next to the glass tube. The results are shown below.



Volume / cm^3	Pressure / x 10^5 Pa
1.5	1.57
1.6	1.48
1.7	1.39
1.8	1.31
1.9	1.24
2.0	1.18

(a) Calculate $\frac{1}{pressure}$ for each value of pressure in the table, to 3 significant figures.
(b) Using the data, draw a line graph of volume against $\frac{1}{pressure}$.
(c) State the relationship between the volume and pressure of a fixed mass of gas.
(d) Explain this relationship in terms of the kinetic theory of particles.

11. Explain, using the appropriate gas law, why a balloon will burst if you squeeze it.

12. A 5 cm^3 syringe is filled with air and the pressure of the air is found to be $1{\cdot}01 \times 10^5$ Pa. The syringe plunger is then pushed until there is 3 cm^3 of air. Calculate the new air pressure.

13. A scuba diving air tank has a volume of 7·5 litres and is filled with air at a pressure of $1{\cdot}21 \times 10^7$ Pa. Calculate what volume of air will be released by the tank at atmospheric pressure ($1{\cdot}01 \times 10^5$ Pa).

14. A weather balloon contains 80 m^3 of helium at normal atmospheric pressure. Calculate the volume of the balloon at an altitude where air pressure is 8×10^4 Pa.

15. A swimmer underwater uses a cylinder of compressed air which holds 15 litres of air at a pressure of 12,000 kPa.
    (a) Calculate the volume this air would occupy at a depth where pressure is 200 kPa.
    (b) If the swimmer breathes 25 litres of air each minute at this pressure, calculate how long the swimmer can remain at this depth.

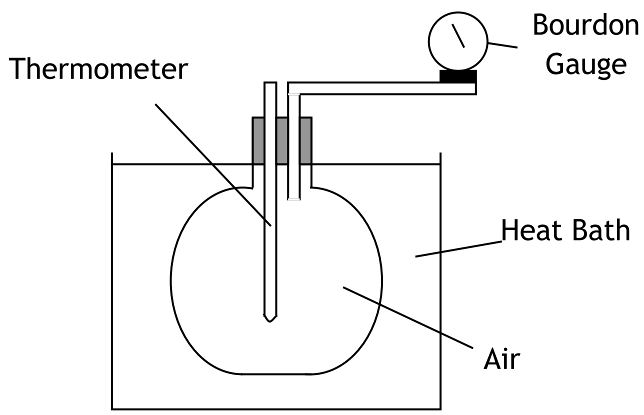
The Pressure Law

16. Explain why the Kelvin temperature scale starts at -273 °C.

17. Convert these temperatures from degrees Celsius to kelvin.
    (a) 0 °C
    (b) 20 °C
    (c) 273 °C
    (d) 100 °C

18. Convert these kelvin temperatures into degrees Celsius:
    (a) 10K
    (b) 23K
    (c) 100K
    (d) 350K

19. A conical flask is sealed with air inside, and is placed in a heat bath. The temperature of the gas increases from 20 °C to 70°C. After every 10 °C temperature increase, the pressure of the gas is measured using a Bourdon gauge. The results are shown below.



Temperature / °C	Pressure / x 10^5 Pa
20	1.01
30	1.04
40	1.08
50	1.11
60	1.15
70	1.18

(a) Using the data, draw a line graph of pressure against temperature (in degrees Celsius). Make sure that your temperature axis goes from -300 °C to 70 °C.
(b) On your graph from part (a), continue your straight line back until it crosses through the x-axis. State the temperature at which the pressure of the gas is zero.
(c) Using the data, draw a line graph of pressure against kelvin temperature.
(d) State the relationship between the pressure and temperature of a fixed mass of gas.
(e) Explain this relationship in terms of the kinetic theory of particles.

20. Explain, using the appropriate gas law, why it is important that car tyres are not filled up with so much air that the air pressure is above the car manufacturer's guidelines.

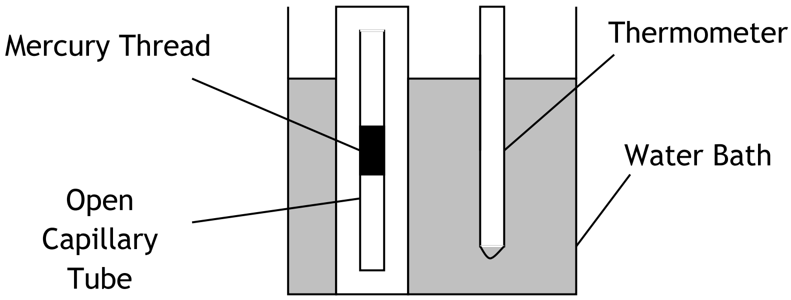
21. At a temperature of 20 °C, the pressure of a fixed mass of gas in a sealed container is found to be 104kPa. The gas is heated to a uniform temperature of 90 °C using a heat bath. Calculate the pressure of the gas at a temperature of 90 °C.

22. The pressure of the air in a lorry tyre is found to be 2.58×10^5 Pa at the end of a journey. Once the tyre has cooled down, the temperature of the air inside the tyre is 10 °C with the and the pressure has decreased to 2.41×10^5 Pa. Calculate the temperature, in degrees Celsius, of the air in the tyre at the end of the journey.

23. A cylinder of oxygen at 27°C has a pressure of 3×10^6 Pa. Calculate the new pressure if the gas is cooled to 0°C.

Charles' Law

24. In an experiment, an open capillary tube with a mercury thread is placed into a water bath. As the temperature of the gas increases, the mercury thread moves up the capillary tube. The pressure of the gas remains constant because the capillary tube is open. The temperature of the gas is measured with a thermometer and the volume of the gas is measured using a scale next to the open capillary tube. The results of the experiment are shown in the table below.



Temperature / °C	*Volume / cm^3*
20	2·45
30	2·55
40	2·64
50	2·70
60	2·78
70	2·84

(a) Using the data, draw a line graph of volume against temperature (in degrees Celsius). Make sure that your temperature axis goes from -300 °C to 100 °C.
(b) Using the data, draw a line graph of volume against temperature (in Kelvin).
(c) State the relationship between the volume of a fixed mass of gas and its temperature.
(d) Explain this relationship in terms of the kinetic theory of particles.

25. The volume of a fixed mass of gas is $30{\cdot}0\ cm^3$ at 30 °C.
The temperature of the gas is increased to 60 °C without changing the pressure.
A student makes this statement:

'As the temperature of the gas has doubled, the volume of the gas will also double. Therefore, the volume of the gas at 60 °C will be 60.0 cm³.'

(a) Explain why this statement is incorrect.
(b) Calculate what the volume of the gas would actually be at 60 °C.

26. Air is trapped in a glass capillary tube by a bead of mercury.
The volume of air is found to be $0{\cdot}15\ cm^3$ at a temperature of 27 °C.
Assuming that the pressure of the air remains constant, what is the volume of the air at a temperature of 87 °C?

27. A fixed mass of gas is trapped into a syringe. The gas has a pressure of $1{\cdot}63 \times 10^5$ Pa when it has a volume of $3{\cdot}0\ cm^3$ and a temperature of 22 °C. The gas is then heated until it has a uniform temperature of 57 °C. What will be the pressure of the gas if the volume of the gas is increased to $5{\cdot}0\ cm^3$?

28. The volume of a fixed mass of gas at a constant temperature is found to be $50\ cm^3$. The pressure remains constant and the temperature increases from 20 °C to 40 °C.
(a) Explain why the new volume of the gas is not $100\ cm^3$.
(b) Calculate the new volume of the gas.

The General Gas Equation

29. Find the unknown quantity from the readings shown below for a fixed mass of gas:

(a) $p_1 = 2 \times 10^5$ Pa $\quad V_1 = 50\ cm^3 \quad T_1 = 20$ °C
$p_2 = 3 \times 10^5$ Pa $\quad V_2 = ? \quad T_2 = 80$ °C

(b) $p_1 = 1 \times 10^5$ Pa $\quad V_1 = 75\ cm^3 \quad T_1 = 20$ °C
$p_2 = 2.5 \times 10^5$ Pa $\quad V_2 = 100\ cm^3 \quad T_2 = ?$

(c) $p_1 = 2 \times 10^5$ Pa $\quad V_1 = 60\ cm^3 \quad T_1 = 20$ °C
$p_2 = ?$ $\quad V_2 = 80\ cm^3 \quad T_2 = 150$ °C

(d) $p_1 = 1 \times 10^5$ Pa $\quad V_1 = 75\ cm^3 \quad T_1 = ?$
$p_2 = 2{\cdot}5 \times 10^5$ Pa $\quad V_2 = 50\ cm^3 \quad T_2 = 40$ °C

32. A sealed syringe contains $100\ cm^3$ of air at atmospheric pressure and a temperature of 27 °C. When the piston is depressed, the volume of air in the syringe is reduced to $20\ cm^3$ and this produces a temperature rise of 4 °C. Calculate the new pressure of the air in the syringe.