3.1 Conservation of Energy

Energy Changers

1) • Electrical
• Nuclear
• Potential
• Chemical
• Kinetic
• Light
• Sound
• Heat

2) Energy cannot be created or destroyed only change from one form to another.

3) Joules (J)

4) a) Electrical energy → Heat energy

b) Electrical energy → Light + Heat energy

c) Potential energy → Kinetic energy

d) Electrical energy → Sound energy

e) Chemical energy → Heat + Light energy

Work

1) $E_W = Fd$

$= 250 \times 20$

$= 5000\,J$

2) $E_W = Fd$

$1500 = F \times 50$

$F = \frac{1500}{50}$

$= 30\,N$

3) $E_W = Fd$

$8.5 \times 10^6 = 2.5 \times 10^3 \times d$

$d = \frac{8.5 \times 10^6}{2.5 \times 10^3}$

$= 3400\,m$

4) $E_W = Fd$

$200\times10^6 = 110\times10^3 \times d$

$d = \frac{200\times10^6}{110\times10^3}$

$= \underline{1800m}$

5) a) $E_W = Fd$

$650\times10^6 = F \times 1500\times10^3$

$F = \frac{650\times10^6}{1500\times10^3}$

$= \underline{430N}$

b) $\frac{430}{8} = \underline{54N}$

6) a) $E_W = Fd$

$650\times10^3 = F \times 40$

$F = \frac{650\times10^3}{40}$

$= \underline{16300N}$

b) $W = mg$

$16300 = m \times 9.8$

$m = \frac{16300}{9.8}$

$= \underline{1660kg}$

7) a) $E_W = Fd$

$= 350\times150$

$= \underline{52500J}$

b) $E_W = Fd$

$= 525\times100$

$= \underline{52500J}$

c) I) Peter: $\frac{80}{10} = 8$ ~~trol~~ journeys   John: $\frac{80}{20} = 4$ journeys

II) Peter: $E = 8\times52500$

$= 420000J$

John: $E = 4\times52500$

$= 210000J$

Peter does more work.

8) $E_W = Fd$
$= 600 \times 8$
$= 4800J$

9) $E_W = Fd$
$= 1500 \times 500$
$= 750000J$

10) a) $W = mg$
$= 0.45 \times 9.8$
$= 4.41N$
4.41×150
$= 662N$

b) $E_W = Fd$
$= 662 \times 1.4$
$= 927J$

c) $E_W = F9$
$= 662 \times 2$
$= 1324J$
$1324 - 927$
$= 397J$

Potential Energy

1) An object gains potential energy by being lifted to a height in a gravitational field.

2) $E_p = m g h$
E_p ↑ J, m ↑ kg, g ↑ $\frac{N}{kg}$, h ↑ m

3)

	Mass (kg)	Gravitational Field Strength (N/kg)	Height (m)	Potential Energy (J)
a)	25	9.8	15	3675
b)	30	9.8	45	13230
c)	35	9.8	1.3	450
d)	2	9.8	0.36	70
e)	2.4	9.8	5	120
f)	10.7	9.8	57	6000

4) $E_p = mgh$
$= 70 \times 9.8 \times 60$
$= 41200J$

5) $E_p = mgh$
$= 1200 \times 9.8 \times 40$
$= 470400J$

6) $E_p = mgh$
$= 0.03 \times 9.8 \times 2$
$= 0.59J$

7) $E_p = mgh$

$78000 = m \times 9.8 \times 120$

$m = \frac{78000}{9.8 \times 120}$

$= 66.3kg$

8) $E_p = mgh$

$120 \times 10^6 = 120000 \times 9.8 \times h$

$h = \frac{120 \times 10^6}{120000 \times 9.8}$

$= 102m$

9) a) $E_p = mgh$

$= 85 \times 9.8 \times 440$

$= 366520J$

b) $h = 440 - 250 = 190m$

$E_p = mgh$

$= 85 \times 9.8 \times 190$

$= 158270J$

10) a) $200 - 180 = 20J$ b) Heat (and Sound)

Kinetic Energy

1)

	Mass(kg)	Velocity (ms^{-1})	Kinetic Energy (J)
a)	2.0	3.0	9.0
b)	0.5	15.0	56.3
c)	4.5	4.0	36.0
d)	4.0	5.0	50.0
e)	0.24	10.0	12.0
f)	20	200.0	400000.0

2) $E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 1200 \times 15^2$

$= 135000 J$

3) $E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 2 \times 4.4^2$

$= 19.4J$

4) $E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 70 \times 5.4^2$

$= 1021J$

5) a) 72 km/h

$= 72000 m/h$

$= \frac{72000}{60 \times 60}$

$= 20ms^{-1}$

b) $E_k = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 50000 \times 20^2$

$= 10000000 J$

$= 1 \times 10^7 J$

6) Before

$E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 4500 \times 6000^2$

$= 8.1 \times 10^{10}$ J

After

$E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 4500 \times 200^2$

$= 9 \times 10^7$ J

$E_{lost} = 8.1 \times 10^{10} - 9 \times 10^7 = \underline{8.091 \times 10^{10}\ \text{J}}$

7) $E_k = \frac{1}{2} mv^2$

$114 = \frac{1}{2} \times 2.28 \times v^2$

$v = \sqrt{\frac{2 \times 114}{2.28}}$

$= \underline{10\ \text{ms}^{-1}}$

8) $E_k = \frac{1}{2} mv^2$

$0.04 = \frac{1}{2} \times m \times 0.8^2$

$m = \frac{2 \times 0.04}{0.8^2}$

$= \underline{0.125\ \text{kg}}$

9) a) $V = \frac{d}{t}$

$V = \frac{10 \times 10^{-2}}{0.19}$

$= \underline{0.53\ \text{ms}^{-1}}$

b) $E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 0.8 \times 0.53^2$

$= \underline{0.11\ \text{J}}$

10) a) $E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 2800 \times 10^2$

$= \underline{140000\ \text{J}}$

b) $a = \frac{v - u}{t}$

$0.8 = \frac{v - 10}{10}$

$v = 10 + (0.8 \times 10)$

$= \underline{18\ \text{ms}^{-1}}$

) $E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 2800 \times 18^2$

$E_{gain} = 453600 - 140000$

$= \underline{313600\ \text{J}}$

11) a) $E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 350 \times 35^2$

$= 214375 \text{ J}$

$= \underline{214000 \text{ J}}$

b) $E_k = \frac{1}{2} mv^2$

$214000 = \frac{1}{2} \times 5000 \times v^2$

$v = \sqrt{\frac{2 \times 214000}{5000}}$

$= \underline{9.25 \text{ ms}^{-1}}$

12) Before

$E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 0.05 \times 10^2$

$= \underline{2.5 \text{ J}}$

After

$E_k = 2.5 - 0.475$

$= 2.025 \text{ J}$

$E_k = \frac{1}{2} mv^2$

$2.025 = \frac{1}{2} \times 0.05 \times v^2$

$v = \sqrt{\frac{2 \times 2.025}{0.05}}$

$= \underline{9 \text{ ms}^{-1}}$

Conservation of Energy

1) a) $E_p = mgh$

$= 2 \times 9.8 \times 3$

$= \underline{58.8 \text{ J}}$

b) $E_p = E_k$

$E_k = \underline{58.8 \text{ J}}$

c) $E_k = \frac{1}{2} mv^2$

$58.8 = \frac{1}{2} \times 2 \times v^2$

$v = \sqrt{\frac{2 \times 58.8}{2}}$

$= \underline{7.7 \text{ ms}^{-1}}$

2) a) $E_k = \frac{1}{2} m v^2$

$= \frac{1}{2} \times 0.3 \times 2^2$

$= \underline{0.6\,J}$

b) $E_p = E_k$

$= \underline{0.6\,J}$

c) $E_p = mgh$

$0.6 = 0.3 \times 9.8 \times h$

$h = \frac{0.6}{0.3 \times 9.8}$

$= \underline{0.2\,m}$

3) a) $E_p = mgh$

$= 8 \times 9.8 \times 20$

$= \underline{1568\,J}$

b) $E_k = \frac{1}{2} m v^2$

$1568 = \frac{1}{2} \times 8 \times v^2$

$v = \sqrt{\frac{2 \times 1568}{8}}$

$= \underline{19.8\,ms^{-1}}$

4) $E_p = E_k$

$\cancel{m}gh = \frac{1}{2} \cancel{m} v^2$

$2gh = v^2$

$v = \sqrt{2gh}$

$v = \sqrt{2gh}$

$= \sqrt{2 \times 9.8 \times 10}$

$= \underline{14\,ms^{-1}}$

5) $v = \sqrt{2gh}$

$150 = \sqrt{2 \times 9.8 \times h}$

$h = \frac{150^2}{2 \times 9.8}$

$= \underline{115\,m}$

6) a) $E_p = mgh$

$= 3000 \times 9.8 \times 15$

$= \underline{441000\,J}$

b) $E_k = \frac{1}{2} m v^2$

$= \frac{1}{2} \times 3000 \times 8^2$

$= 96000\,J$

6) c) $E_p = 441000 - 96000 - 6000$
$= \underline{339000\,J}$

d) $E_p = mgh$
$339000 = 3000 \times 9.8 \times h$
$h = \frac{339000}{3000 \times 9.8}$
$= \underline{11.5\,m}$

7) a) $E_p = mgh$
$= 1500 \times 9.8 \times 20$
$= \underline{294000\,J}$

b) $E_k = \frac{1}{2}mv^2$
$= \frac{1}{2} \times 1500 \times 18^2$
$= \underline{243000\,J}$

c) $E_{lost} = E_p - E_k$
$= 294000 - 243000$
$= \underline{51000\,J}$

8) a) $E_p = mgh$
$= 0.4 \times 9.8 \times 0.1$
$= \underline{0.392\,J}$

b) $E_k = E_p$
$E_k = \underline{0.392\,J}$

c) $E_k = \frac{1}{2}mv^2$
$0.392 = \frac{1}{2} \times 0.4 \times v^2$
$v = \sqrt{\frac{2 \times 0.392}{0.4}}$
$= \underline{1.4\,ms^{-1}}$

Power

1) Power is the energy transferred per second.

2) (W) $P = \frac{E}{t}$ (J) (s)

3)

	Power (W)	Energy (J)	Time (s)
a)	2433	36500	15
b)	58.6	7320	125
c)	65	650	10
d)	1.2×10^4	3600	0.3
e)	100	6×10^3	60
f)	2.5×10^4	540	0.22

4) $P = \frac{E}{t}$

$P = \frac{135}{4}$

$= 33.8W$

5) $P = \frac{E}{t}$

$= \frac{350}{30}$

$= 11.7W$

6) $P = \frac{E}{t}$

$20 = \frac{E}{45}$

$E = 20\times45$

$= 900J$

7) Ferrari

$P = \frac{E}{t}$

$100\times10^3 = \frac{E}{8\times60}$

$E = 100\times10^3\times8\times60$

$= 48\times10^6 J$

$= 48 MJ$

Fiat

$P = \frac{E}{t}$

$45\times10^3 = \frac{E}{8\times60}$

$E = 45\times10^3\times8\times60$

$= 21.6\times10^6 J$

$= 21.6 MJ$

8) a) $E_w = Fd$

$= 130 \times 1 \times 10^3$

$= 130000 J$

$= 130 kJ$

b) $P = \frac{E}{t}$

$= \frac{130000}{3 \times 60}$

$= 722 W$

9) a) $E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 80000 \times 30^2$

$= 36000000 J$

$= 36 \times 10^6 J$

b) $E_w = Fd$

$36 \times 10^6 = 750000 \times d$

$d = \frac{36 \times 10^6}{750000}$

$d = 48 m$

∴ The train does not collide with the tree.

c) $P = \frac{E}{t}$

$= \frac{36 \times 10^6}{8}$

$= 4500000 W$

$= 4.5 \times 10^6 W$

10) a) $E_p = mgh$

$= 80 \times 9.8 \times 8$

$= 6272 J$

b) $E_w = Fd$

$= 300 \times 14$

$= 4200 J$

c) $E_k = E_p - E_w$

$= 6272 - 4200$

$= 2072 J$

d) $E_w = Fd$

$2072 = 320 \times d$

$d = \frac{2072}{320}$

$= 6.5 m$

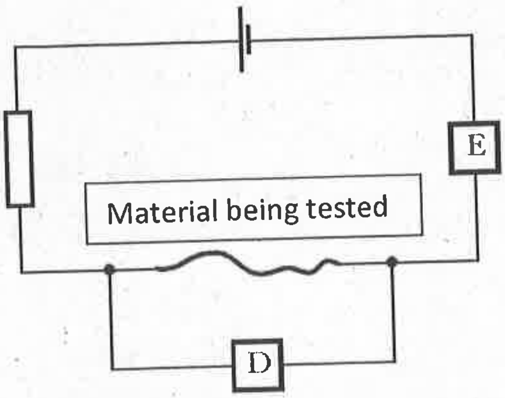
d) $E_k = \frac{1}{2} mv^2$

$2072 = \frac{1}{2} \times 80 \times v^2$

Charge

1.

a. Connect a battery and a bulb in series to two crocodile clips which connect to the test items.
Bulb lights – conductor
Bulb off – insulator



b.

i. Conductors are generally metals.
ii. Graphite (pencil 'lead') is a non-metal conductor.

2. Positive and negative

3. Insulators do not allow electrons to flow through them easily, conductors do. Insulators have high resistance, conductors have low resistance.

4.

a. Electric Current is the rate of flow of charge
OR the flow of charge per second
b. Q = I x t
c. Charge (Coulombs), current (Amperes) and time (seconds).

5.

	Charge (C)	Current (A)	Time (s)
(a)	**150 (200)**	5	30
(b)	**18 (20)**	0·005	3 600
(c)	3	1·5	**2**
(d)	27·6	2·3	**12**
(e)	1 800	**30**	60
(f)	94	**9.4 (9)**	10

6. $Q = I\ t$

$= 1 \times 60$

$= 60\ C$

7. $Q = I\ t$

$756 = I \times 180$

$I = 756/180$

$I = 4.2\ A$

8. $Q = I\ t$

$6000 = 5 \times t$

$t = 6000/5$

$t = 1200$

$= 1000\ s$

9. $Q = I\ t$

$450 = I \times 30 \times 60$

$I = 450/1800$

$I = 0.25$

$I = 0.3\ A$

10. $Q = I\ t$

$1656 = 9.2 \times t$

$t = 1656/9.2$

$t = 180\ S$

11. $Q = I\ t$

$= 12.5 \times ((2 X 60 X60) + (20 X 60))$

$= 12.5 X 8400$

$= 105\ 000\ C$ (100 000 C 1sf)

12.

a. $Q = I\ t$

$= 4 \times 60$

$= 240\ C$ (200 C 1sf)

b. $Q = I\ t$

$440 = I \times 60$

$I = 440/60$

$I = 7.33$

$I = 7\ A$ 1 sf

13.

a. $Q = I\,t$

$= 40 \times 60 \times 60$

$= 144\,000$ C (100 000 C 1sf)

b. $Q = I\,t$

$144\,000 = 2 \times t$

$t = 144\,000/2$

$t = 72\,000$ s (70 000 s 1sf)

c. Assume the battery can supply all of its charge and that the current is constant over this period.

AC/DC

1. a.c. – alternating current d.c. – direct current
   The current is the flow of electrons per second in the conductor. They change direction in ac and have a single direction in dc.

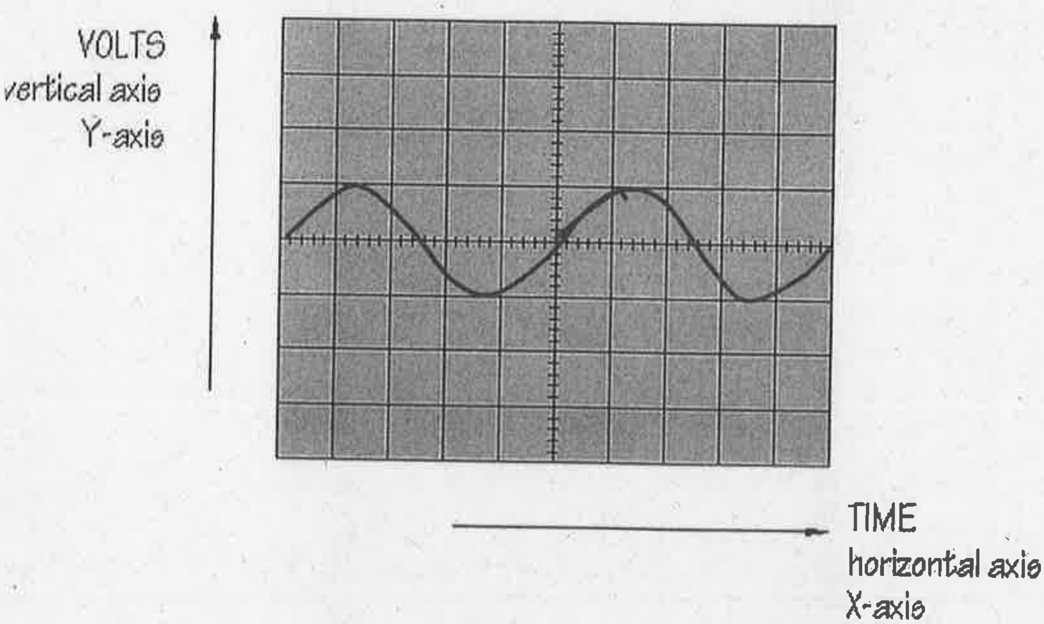
2. (a) a.c. supplies - any turbine generator e.g. coal/oil/gas power stations, wind turbine, tidal generator
   (b) d.c. supplies - batteries, solar (photovoltaic) cells

3. (a) i) dc ii) ac iii) dc
   (b) i) 2 boxes x 1V = 2V
   ii) 3 boxes x 2V = 6V peak
   iii) 3 boxes x 0.5V = 1.5V

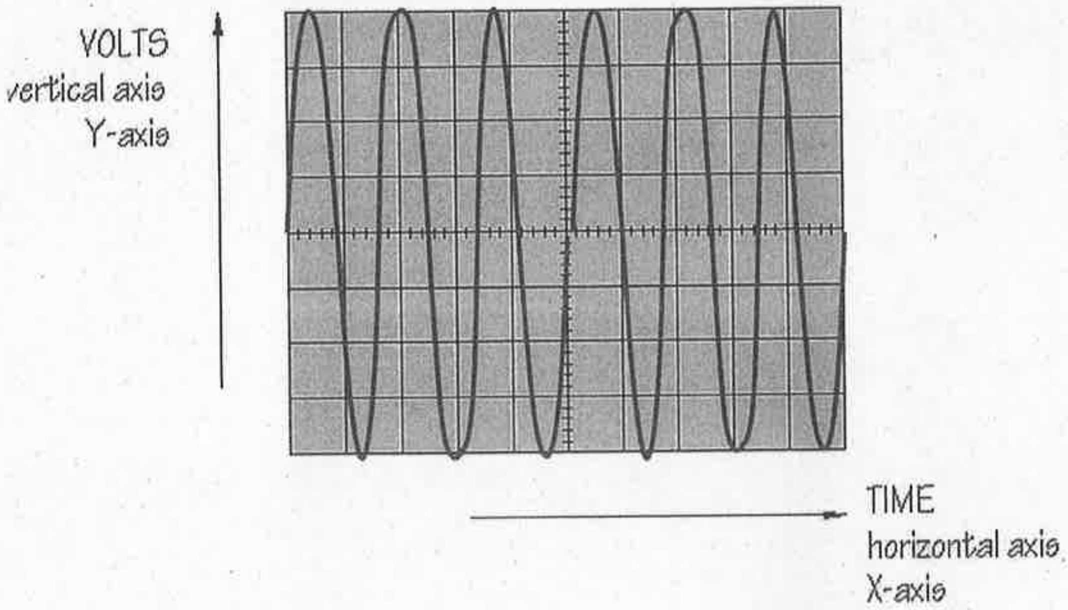
4. (a) 2 boxes x 5 V = 10V
   (b) 4 boxes x 0.1 V = 0.4V
   (c) 3 boxes x 50 mV = 150 mV

5. (a) Mains is a.c (b) Mains frequency is 50Hz

6. (a) The 50 Hz mains signal has 4 waves.
   25 Hz will have only 2 waves on the screen
   (half frequency, half the number of waves)
   At 5V the wave should be 1 box high. Each box is 5V.



(b) 75 Hz will have 6 waves on the screen. (1.5 x frequency so 1.5 times the no of waves) peak 4 boxes high (each box 5V   4 x 5 = 20V)



7. (a) The 5V peak ac voltage will have a lower voltmeter reading or dc equivalent, so it will be less bright than the 5V dc.

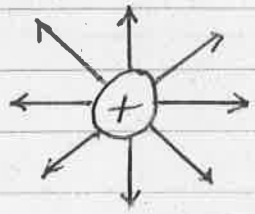
(b) The dc supply has to be decreased to the same 'effective' or rms voltage as would be measured at the ac supply

8. (a) 17 V
(b) If the ac supply is measured at 12V with a voltmeter this is the rms or effective voltage so the peak must be 17V which is greater than 12V.

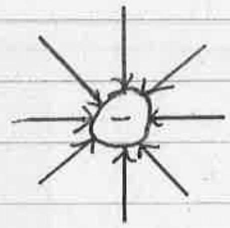
9. The effective voltage is the voltage of an ac supply measured by a voltmeter. It has the same 'effect' as a dc voltage of the same value (e.g. on the brightness of a bulb).

Electric Fields

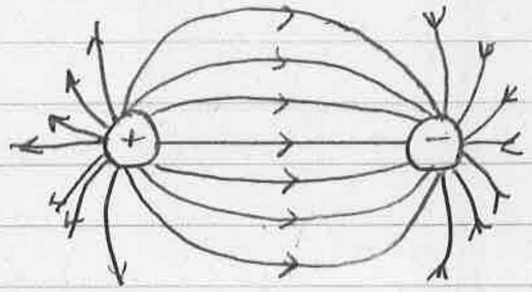
① a.



b.



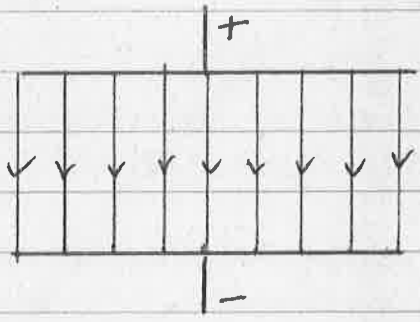
c.



② a. The test charge will be repelled.

b. The test charge will be attracted.

③



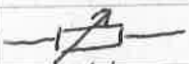
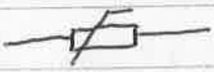
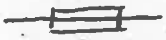
④ a. Y b. Z c. X

⑤ The electric charges will move.

⑥ Voltage is the energy given to each coulomb of charge.

Circuit Components

①

Component	Symbol	Function
Cell		supplies energy to charges
Battery		supplies energy to charges
Lamp		changes electrical → light
Switch		controls flow of current
Resistor		controls the size of current
Variable resistor		alters the size of current
LDR		resistance changes with light
Thermistor		resistance changes with temp.
Voltmeter		measures voltage
Ammeter		measures current
Diode		allows current to flow in 1 dire
LED		changes electrical → light
Fuse		breaks circuit when current hig
Relay		electromagnetic switch

③

1 - voltmeter
2 - ammeter
3 - ammeter
4 - voltmeter
5 - voltmeter
6 - ammeter

Series Circuits

① a. The current is the same at all points in a series circuit. $I_s = I_1 = I_2 ..$

b. The supply voltage is shared across the individual components in a series circuit. $V_s = V_1 + V_2 ...$

② A, C, E

③ 5V

④ 3V

⑤ a. 0.2 V

b. 1.7A

⑥ a. (i) $R = \frac{V}{I}$

$= \frac{6}{0.03}$

$= 200\,\Omega$

(ii) $R = \frac{V}{I}$

$= \frac{6}{0.0024}$

$= 2500\,\Omega$

b. Circuit (ii)

(7) a. $R = \frac{V}{I}$

$= \frac{5}{1.25 \times 10^{-3}}$

$= 4000\ \Omega$

b. The temperature increased during the day as the resistance of the thermistor decreased. This is clear as the current increased.

(8) a. $R = 200\ \Omega$

b. $I = \frac{V}{R}$

$= \frac{12}{2400}$

$= 0.005\ A$

$= 5\ mA$

c. $R = \frac{V}{I}$

$= \frac{12}{0.6}$

$= 20\ \Omega$

$20\ \Omega = 0.02\ k\Omega$

Bright sunlight is the source.

(9) a. $R = \frac{V}{I}$

$= \frac{6}{8 \times 10^{-3}}$

$= 750\,\Omega$

b. The ammeter reading (current) decreases therefore the resistance increases.
If the resistance of the thermistor increases the temperature must go down.
So, cold water must be added.

c. $R = \frac{V}{I}$

$= \frac{6}{1.6 \times 10^{-3}}$

$= 3750\,\Omega$

$T = 20°C$

d. $I = \frac{V}{R}$

$= \frac{6}{200}$

$= 0.03A$

$= 30mA$

Parallel Circuits

(1) a. The supply current splits between the branches of the circuit. $I_s = I_1 + I_2 \ldots$

b. The voltage across each branch of the circuit is equal to the supply voltage. $V_s = V_1 = V_2 \ldots$

(2) a. 12 V

b. 12 V

c. 0.5 A

(3) a. 230 V

b. 0.6 A

c. 0.9 A

(4) B, D, F

(5) a. 12 V

b. 12 V

c. 6 A

d. 16 A

⑥ a. $V_s = 13\ V$ $I_1 = 0.4A$

b. $V_1 = 9V$ $I_2 = 1.5A$

c. $V_2 = 9V$ $I_3 = 0.8\ A$ $I_4 = 0.8A$

d. $V_3 = 4V$ $I_5 = 1.5A$ $I_6 = 1A$

Resistors in a Series Circuit

1) $R_T = R_1 + R_2 + R_3$

2)

	$R_1 (\Omega)$	$R_2 (\Omega)$	$R_3 (\Omega)$	$R_T (\Omega)$
a)	5000	490	85	5575
b)	80	300	25	405
c)	800	2000	200	3000
d)	700	300	400	1400
e)	310	140	100	550

3) $R_T = R_1 + R_2 + R_3$
$= 800 + 5\times10^3 + 3.2\times10^3$
$= \underline{9000\,\Omega}$

4) $R_T = R_1 + R_2 + R_3$
$8.8\times10^3 = 950 + R_2 + 6.3\times10^3$
$R_2 = 8.8\times10^3 - 950 - 6.3\times10^3$
$= \underline{1550\,\Omega}$

Resistors in a Parallel Circuit

1) a) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ *
$= \frac{1}{80} + \frac{1}{80}$
$R_T = \underline{40\,\Omega}$

b) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
$= \frac{1}{120} + \frac{1}{120}$
$R_T = \underline{60\,\Omega}$

c) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
$= \frac{1}{100} + \frac{1}{400}$
$R_1 = \underline{80\,\Omega}$

d) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
$= \frac{1}{1200} + \frac{1}{600}$
$= \underline{400\,\Omega}$

e) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$= \frac{1}{600} + \frac{1}{600} + \frac{1}{600}$

$= \underline{\underline{200\,\Omega}}$

f) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$= \frac{1}{1.2\times10^3} + \frac{1}{600} + \frac{1}{600}$

$= \underline{\underline{240\,\Omega}}$

2) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{80} = \frac{1}{R_1} + \frac{1}{220} + \frac{1}{1232}$

$\frac{1}{R_1} = \frac{1}{80} - \frac{1}{220} - \frac{1}{1232}$

$R_1 = \underline{\underline{140\,\Omega}}$

3) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{112.5} = \frac{1}{300} + \frac{1}{R_2} + \frac{1}{900}$

$\frac{1}{R_2} = \frac{1}{112.5} - \frac{1}{300} - \frac{1}{900}$

$R_2 = \underline{\underline{225\,\Omega}}$

Combination Circuits

1) a) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{20} + \frac{1}{20}$

$R_T = 10\,\Omega$

$R_T = R_1 + R_2$

$= 10 + 10$

$= \underline{\underline{20\,\Omega}}$

b) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{60} + \frac{1}{60}$

$R_T = 30\Omega$

$R_T = R_1 + R_2$

$= 30 + 40$

$= 70\Omega$

c) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{10} + \frac{1}{10}$

$R_T = 5\Omega$

$R_T = R_1 + R_2 + R_3$

$= 10 + 5 + 10$

$= 25\Omega$

d) $R_T = R_1 + R_2$

$= 15 + 15$

$= 30\Omega$

$R_T = R_1 + R_2$

$= 30 + 30$

$= 60\Omega$

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{30} + \frac{1}{60}$

$R_T = 20\Omega$

e) $R_T = R_1 + R_2$

$= 10 + 100$

$= 110\Omega$

$R_T = R_1 + R_2$

$= 100 + 10$

$= 110\Omega$

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{110} + \frac{1}{110}$

$R_T = 55\Omega$

f) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{5} + \frac{1}{5}$

$R_T = 2.5\Omega$

$R_T = R_1 + R_2 + R_3$

$= 10 + 2.5 + 10$

$= \underline{\underline{22.5\Omega}}$

2) a) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{250} + \frac{1}{250}$

$= \underline{\underline{125\Omega}}$

b) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{560} + \frac{1}{560}$

$= \underline{\underline{280\Omega}}$

c) $R_T = R_1 + R_2$

$= 125 + 280$

$= \underline{\underline{405\Omega}}$

3) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

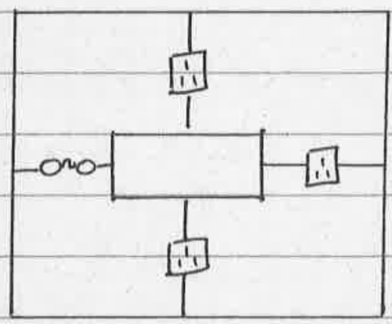
$= \frac{1}{80} + \frac{1}{60}$

$R_T = 34.3\Omega$

$R_T = R_1 + R_2 + R_3 + R_4$

$= 40 + 80 + 34.3 + 120$

$= \underline{\underline{274.3\Omega}}$

4) 

5) · Less copper is needed as thinner cables are needed.
· Each cable carries less current.
· Sockets can be placed at any point on the circuit

Ohm's Law

1) 0.002A, 0.029A, 0.03A, 5.805A, 8.9A, 120A

2) a) Current

b)

Resistor (Ω)	Current
5	1.2A
10	0.6A
20	240mA
2.5k	2.4mA

3) a) $V = IR$
$= 10 \times 5$
$= \underline{50V}$

b) $V = IR$
$= 50 \times 10^{-3} \times 480$
$= \underline{24V}$

4) a) $V = IR$
$24 = I \times 12$
$I = \frac{24}{12}$
$= \underline{2A}$

b) $V = IR$
$48 = I \times 550$
$I = \frac{48}{550}$
$= \underline{87.3 \times 10^{-3} A}$

5) a) $V = IR$
$24 = 25 \times 10^{-3} \times R$
$R = \frac{24}{25 \times 10^{-3}}$
$= \underline{960 \Omega}$

b) $V = IR$
$48 = 660 \times 10^{-6} \times R$
$R = \frac{48}{660 \times 10^{-6}}$
$= \underline{73000 \Omega}$

6) $V = IR$
$24 = 10 \times 10^{-3} \times R$
$R = \frac{24}{10 \times 10^{-3}}$
$= \underline{2400 \Omega}$

7) $V = IR$
$230 = I \times 1.5 \times 10^{3}$
$I = \frac{230}{1.5 \times 10^{3}}$
$= \underline{0.15A}$

8) $V = IR$

$= 10 \times 10^{-3} \times 360$

$= \underline{3.6V}$

9) $V = IR$

$230 = 15 \times 10^{-3} \times R$

$R = \frac{230}{15 \times 10^{-3}}$

$= \underline{15300\Omega}$

10) $V = IR$

$4000 = I \times 25 \times 10^{3}$

$I = \frac{4000}{25 \times 10^{3}}$

$= \underline{0.16A}$

11) a) $\underline{18V}$

b) $V = IR$

$18 = 60 \times 10^{-3} \times R$

$R = \frac{18}{60 \times 10^{-3}}$

$= \underline{300\Omega}$

12) a)

V (V)	I (A)	V/I (Ohms)
2.4	0.24	10
3.1	0.30	10.3
3.6	0.34	10.6
4.8	0.40	12

V (V)	I (A)	V/I (Ohms)
2.4	0.24	10
3.0	0.30	10
3.4	0.34	10
4.0	0.40	10

b) To change the current in the circuit.

c) The resistance of the lamp increases as the current increases.

d) The resistance of the resistor stays constant as the current increases

e) As the current in the bulb increases the wire heats up causing the change in resistanc This does not happen in the resistor.

Ohm's Law Graphical Analysis

1) a) Voltage and Current are directly proportional
$V = IR$

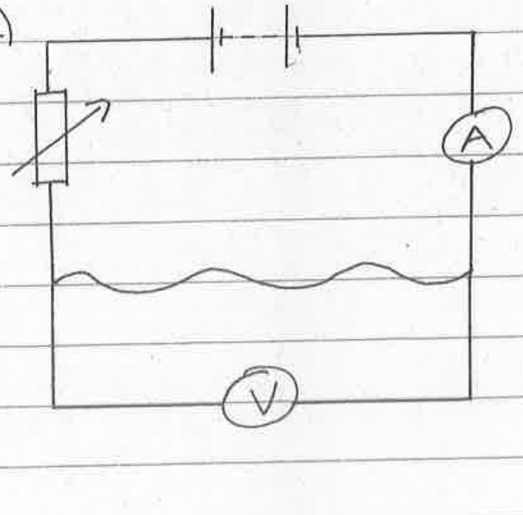
b) $m = \frac{y_2 - y_1}{x_2 - x_1}$ or $V = IR$

$= \frac{8-0}{4-0}$ $8 = 4 \times R$

$= \underline{\underline{2\Omega}}$ $R = \frac{8}{4}$

$= \underline{\underline{2\Omega}}$

2) a)



b) I) The student uses the variable resistor to change the current in the circui They then take voltag readings for differen currents.

b) II) $V = IR$

$4 = 1 \times R$

$R = \frac{4}{1}$

$= \underline{4\,\Omega}$

$1m = 5 \times 200mm$

$\therefore R_{1m} = 5 \times 4$

$= \underline{20\,\Omega}$

3) B

LED Circuits

1) B, E only

2)

	V_{supply} (V)	V_{LED} (V)	Current (A)	V_R (V)	Resistance of R (Ω)
a)	6	2.0	0.010	4	400
b)	12	2.0	0.010	10	1000
c)	8	1.8	0.016	6.2	387.5
d)	20	1.6	0.008	18.4	2300
e)	4	1.5	0.020	2.5	125
f)	11	2.0	0.012	9	750

3) a) $V = IR$

$1.9 = 10 \times 10^{-3} \times R$

$R = \frac{1.9}{10 \times 10^{-3}}$

$= \underline{190\,\Omega}$

b) $V = IR$

$6.5 = 10 \times 10^{-3} \times R$

$R = \frac{6.5}{10 \times 10^{-3}}$

$= \underline{650\,\Omega}$

4) $V = IR$

$10.2 = I \times 2040$

$I = \frac{10.2}{2040}$

$= \underline{0.005A}$

5) $V = IR$

$5 = 20 \times 10^{-3} \times R$

$R = \frac{5}{20 \times 10^{-3}}$

$= \underline{250\,\Omega}$

Potential Dividers

1) a) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{10}{10+10}\right) \times 12$

$= \underline{\underline{6V}}$

$V_1 = V_s - V_2$

$= 12 - 6$

$= \underline{\underline{6V}}$

b) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{6}{6+6}\right) \times 24$

$= \underline{\underline{12V}}$

$V_1 = V_s - V_2$

$= 24 - 12$

$= \underline{\underline{12V}}$

c) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{16}{20+16}\right) \times 36$

$= \underline{\underline{16V}}$

$V_1 = V_s - V_2$

$= 36 - 16$

$= \underline{\underline{20V}}$

d) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{3}{9+3}\right) \times 36$

$= \underline{\underline{9V}}$

$V_1 = V_s - V_2$

$= 36 - 9$

$= \underline{\underline{27V}}$

e) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{4}{12+4}\right) \times 36$

$= \underline{\underline{9V}}$

$V_1 = V_s - V_2$

$= 36 - 9$

$= \underline{\underline{27V}}$

f) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{7}{21 + 7}\right) \times 36$

$= \underline{\underline{9V}}$

$V_1 = V_s - V_2$

$= 36 - 9$

$= \underline{\underline{27V}}$

2) a) I) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{4000}{100 + 4000}\right) \times 230$

$= \underline{\underline{224V}}$

II) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$

$= \left(\frac{1980}{100 + 1980}\right) \times 230$

$= \underline{\underline{219V}}$

b) I) $V_1 = \left(\frac{R_1}{R_1 + R_2}\right) V_s$

$= \left(\frac{10000}{10000 + 1000}\right) \times 12$

$= \underline{\underline{10.9V}}$

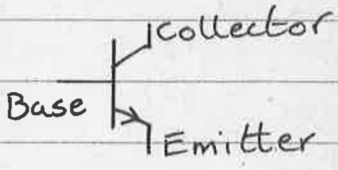
II) $V_1 = \left(\frac{R_1}{R_1 + R_2}\right) V_s$

$= \left(\frac{2500}{1000 + 2500}\right) \times 12$

$= \underline{\underline{8.6V}}$

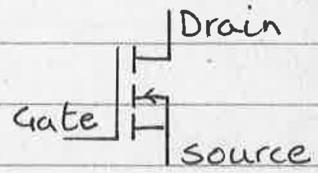
Transistors

1)



2) Metal Oxide Semiconductor Field Effect Transistor

3)



4) a) 0.7V b) 2-2.5V

5) a) Base and Emitter

b) Gate and Source

6) a) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$ ∴ Output is ON

$= \left(\frac{400}{400+400}\right) \times 12$

$= \underline{6V}$

b) $V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_s$ ∴ Output is ON

$= \left(\frac{400}{800+400}\right) \times 6$

$= \underline{2V}$

7) a) When the temperature of the room drops the resistance of the thermistor increases. The voltage accross the thermistor also increases. Until it reaches the switch on voltage of the MOSFET and the heater turns on.

b) Decreasing the resistance of the variable resistor would cause the heater to come on at a higher temperature.

c) The heater needs a much higher voltage then the MOSFET.

8) a) Circuit D
When the light level drops the resistance of the LDR will increase. The voltage accros the LDR will increase until it reaches the switch on voltage of the MOSFET and the buzzer turns on.

b) Circuit B

When the temperature drops the resistance of the thermistor will increase. The voltage accross the thermistor will increase until it reaches 0.7V and the buzzer turns on.

c) Circuit C

When it gets bright the resistance of the LDR will decrease. The voltage accross the resistor will increase until it reaches the switch on voltage of the MOSFET and the buzzer turns on.

d) Circuit A

Electrical Power

1) a) Electrical Energy → Heat Energy

b)
- Hob
- Oven
- Electric Heater
- Toaster
- Hair Drier
- Straighteners
- Kettle
- Grill

2) a) $P = \frac{E}{t}$

$60 = \frac{E}{1}$

$E = 60 \times 1$

$= 60J$

b) Electrical Energy → Light + Heat Energy

3) a) $P = \frac{E}{t}$

$= \frac{207 \times 10^3}{30 \times 60}$

$= \underline{115\,W}$

b) Electrical Energy → Kinetic Energy

4) a) $P = \frac{E}{t}$

$400 = \frac{E}{45}$

$400 \times 45 = E$

$E = \underline{18000\,J}$

b) $P = \frac{E}{t}$

$800 = \frac{E}{40 \times 60}$

$E = 800 \times (40 \times 60)$

$= \underline{1920000\,J}$

c) $P = \frac{E}{t}$

$2.4 \times 10^3 = \frac{E}{5 \times 60}$

$E = 2.4 \times 10^3 \times (5 \times 60$

$= \underline{720000\,J}$

5) $P = \frac{E}{t}$

$2 \times 10^3 = \frac{100 \times 10^3}{t}$

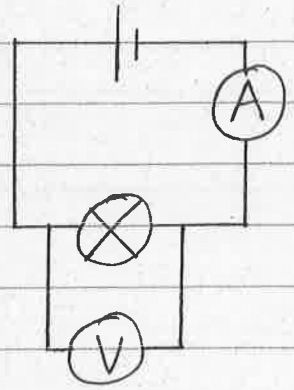
$t = \frac{100 \times 10^3}{2 \times 10^3}$

$= \underline{50s}$

6)

	Power (W)	Current (A)	Voltage (V)
a)	30	2.5	12
b)	5.4	0.6	9
c)	1.5×10^3	6.5	230
d)	36	3	12
e)	0.624	2.6×10^{-3}	240
f)	1.5	0.25	6

7) a)



b) $P = IV$

$= 600 \times 10^{-3} \times 6$

$= \underline{3.6W}$

c) $P = \frac{E}{t}$

$3.6 = \frac{E}{60 \times 60}$

$E = 3.6 \times (60 \times 60)$

$= \underline{12960 J}$

8) a) $P = IV$

$300 = I \times 230$

$I = \frac{300}{230}$

$= \underline{1.3A}$

b) $P = \frac{E}{t}$

$300 = \frac{E}{8 \times 60 \times 60}$

$E = 300 \times (8 \times 60 \times 60)$

$= \underline{8640000 J}$

9) $P = IV$

$= 3.3 \times 230$

$= \underline{759W}$

10) $P = IV$

$0.1 \times 10^6 = I \times 230$

$I = \frac{0.1 \times 10^6}{230}$

$= \underline{434.8W}$

11) $P = IV$

$6 = 500 \times 10^{-3} \times V$

$V = \frac{6}{500 \times 10^{-3}}$

$= \underline{12V}$

12) $P = IV$

$120 = I \times 230$

$I = \frac{120}{230}$

$= \underline{0.52A}$

13) a) $P = IV$ and $V = IR$

$\Rightarrow P = I(IR)$

$\underline{P = I^2R}$

b) $P = I^2R$

$= 8^2 \times 30$

$= \underline{1920W}$

14) a) $P = I^2R$

$= 2^2 \times 6$

$= \underline{\underline{24W}}$

b) $P = I^2R$

$= 4^2 \times 3$

$= \underline{\underline{48W}}$

15) a) $P = IV$

$2\times10^3 = I \times 230$

$I = \frac{2\times10^3}{230}$

$= \underline{\underline{8.7A}}$

b) $V = IR$

$230 = 8.7 \times R$

$R = \frac{230}{8.7}$

$= \underline{\underline{26.4\Omega}}$

16) $P = I^2R$

$960 = 4^2 \times R$

$R = \frac{960}{4^2}$

$= \underline{\underline{60\Omega}}$

17) $P = IV$ and $V = IR$ so $I = \frac{V}{R}$

$\Downarrow$

$P = \frac{V}{R} \times V$

$P = \underline{\underline{\frac{V^2}{R}}}$

18) $P = \frac{V^2}{R}$

$= \frac{230^2}{53}$

$= \underline{\underline{998W}}$

19) a) To protect the flex if the current is too high.

b) Electrical Energy → Heat Energy

c)

Appliance	Power	Voltage (V)	Current (A)	Fuse
Food Mixer	69	230	0·3	3A
Lamp	100W	230	0·4	3A
Heater	2·5kW	230	10·9	13A
Hi-fi Unit	345	230	1·5	3A

20) a) I) $P = I^2R$
$= 6^2 \times 0{\cdot}2$
$= 7{\cdot}2W$

II) $P = I^2R$
$= 6^2 \times 60$
$= 2160W$

b) I) Electrical Energy → Heat Energy

II) The wire is producing a small amount of energy which is able to escape to the surroundings.

c) I) 13A

II) If the three amp fuse were fitted the current would be too high and it would blow stopping the current.

3·5 Heat

Heat and Specific Heat Capacity

1) a) 200g = 0·2kg b) 12g = 0·012kg c) 3·5g = 0·0035kg
d) 0·24g = $2 \cdot 4 \times 10^{-4}$ kg e) 0·05g = 5×10^{-5} kg f) 36mg = $3 \cdot 6 \times 10^{-5}$ kg
g) 7·5mg = $7 \cdot 5 \times 10^{-6}$ kg

2) Heat is energy which can be transferred (J)
Temperature is a measure of how hot or cold something is. (°C)

3) 4180 J of energy is needed to raise 1kg of water by 1°C

4)

	Heat Energy (J)	Specific Heat Capacity ($J\,kg^{-1}\,°C^{-1}$)	Mass (kg)	Change in Temperature (°C)
a)	47000	2350	2.0	10
b)	112750	402	5.0	25
c)	36900	4100	4.5	2
d)	6885	270	0.75	34
e)	10080	2100	0.4	12
f)	105600	480	5.5	40

5) $E_h = cm\Delta T$

$10000 = c \times 1 \times 2$

$c = \frac{10000}{1 \times 2}$

$= 5000\ J\,kg^{-1}\,°C^{-1}$

$E_h = cm\Delta T$

$= 5000 \times 4 \times 1$

$= 20000\ J$

6) $E_h = cm\Delta T$

$= 800 \times 50 \times 100$

$= 4 \times 10^6\ J$

7) $E_h = cm\Delta T$

$1{\cdot}344\times10^6 = 4200\times m\times 80$

$m = \dfrac{1{\cdot}344\times10^6}{4200\times80}$

$= \underline{4\,kg}$

8) $E_h = cm\Delta T$

$9600 = 2300\times1\times\Delta T$

$\Delta T = \dfrac{9600}{2300\times1}$

$= \underline{4{\cdot}17°C}$

9) a) $E_h = cm\Delta T$

$4\times10^4 = c\times4\times4$

$c = \dfrac{4\times10^4}{4\times4}$

$= \underline{2500\,J\,kg^{-1}\,°C^{-1}}$

b) The result is higher than the theoretical value so heat must have been lost to the surroundings

10) $E_h = cm\Delta T$

$= 4180\times2\times15$

$= \underline{125400\,J}$

11) $E_h = cm\Delta T$

$4200 = c\times0{\cdot}8\times50$

$c = \dfrac{4200}{0{\cdot}8\times50}$

$= \underline{105\,J\,kg^{-1}\,°C^{-1}}$

12) $E_h = cm\Delta T$

$= 380 \times 0.03 \times 400$

$= 4560J$

13) $E_h = cm\Delta T$

$30\times10^3 = c \times 2 \times 30$

$c = \frac{30\times10^3}{2\times30}$

$= 500 J kg^{-1} {}^\circ C^{-1}$

Latent Heat

1) $E_h = mL$

$= 0.3 \times 3.34 \times 10^5$

$= 100200J$

2) $E_h = mL$

$6\times10^5 = 4 \times L$

$L = \frac{6\times10^5}{4}$

$= 150\,000 J kg^{-1}$

3) $E_h = mL$

$10.6\times10^3 = m \times 2.26\times10^6$

$m = \frac{10.6\times10^3}{2.26\times10^6}$

$= 4.7\times10^{-3} kg$

4) a) $E_h = mL$

$= 0.001 \times 1.34\times10^6$

$= 1340J$

b) $E_h = mL$

$1340 = m \times 3.34\times10^5$

$m = \frac{1340}{3.34\times10^5}$

$= 4\times10^{-3} kg = 4g$

5) a) AB - Solid, temperature increasing
BC - Solid → Liquid state change (melting)
CD - Liquid, temperature increasing

b) $P = \frac{E}{t}$

$200 = \frac{E}{50}$

$E = 200 \times 50$
$= 10000\ J$

$E_h = mL$
$10000 = 2 \times L$
$L = \frac{10000}{2}$
$= \underline{5000\ J\,kg^{-1}}$

6) a) BC

b) $E_h = mL$
$= 0.02 \times 22.6 \times 10^5$
$= \underline{45200\ J}$

c) $E_h = cm\Delta T$
$= 4180 \times 0.02 \times 100$
$= \underline{8360\ J}$

d) $E_h = mL$
$= 0.02 \times 3.34 \times 10^5$
$= \underline{6680\ J}$

7) a) AB - Solid, T increasing
BC - Melting
CD - Liquid, T increasing
DE - Boiling
EF - Gas, T increasing

b) $E_h = mL$
$1.5 \times 10^5 = m \times 2 \times 10^5$
$m = \frac{1.5 \times 10^5}{2 \times 10^5} = \underline{0.75\ kg}$

c) 290°C

Principles of Conservation of Energy

1) $E_h = cm\Delta T$

$= 4180 \times 0.3 \times 30$

$= 37620 J$

$P = \frac{E}{t}$

$= \frac{37620}{120}$

$= 313.5 W$

2) a) $E_h = cm\Delta T$

$= 4180 \times 0.3 \times 80$

$= 100320 J$

$P = \frac{E}{t}$

$350 = \frac{100320}{t}$

$t = \frac{100320}{350}$

$= 287 s$

b) No energy is lost to the surroundings

3) $E_k = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 0.001 \times 30000^2$

$= 450000 J$

$E_h = cm\Delta T$

$450000 = c \times 0.001 \times 20000$

$c = \frac{450000}{0.001 \times 20000}$

$= 22500 \text{ J kg}^{-1} \text{°C}^{-1}$

4) $E_p = E_h$

$mgh = cm\Delta T$

$h = \frac{cm\Delta T}{mg}$

$= \frac{c\Delta T}{g}$

$= \frac{380 \times 2}{9.8}$

$= 77.6 m$

5) a) $P = \frac{E}{t}$

$1500 = \frac{E}{300}$

$E = 1500 \times 300$

$= \underline{450000 J}$

b) $E_h = cm\Delta T$

$450000 = 4180 \times 5 \times \Delta T$

$\Delta T = \frac{450000}{4180 \times 5}$

$= \underline{21.5°C}$

6) $P = IV$

$= 2 \times 20$

$= 40W$

$P = \frac{E}{t}$

$40 = \frac{E}{100}$

$E = 40 \times 100$

$= 4000 J$

$E = mL$

$4000 = 0.02 \times L$

$L = \frac{4000}{0.02}$

$= \underline{200000 J kg^{-1}}$

7) a) $E_h = cm\Delta T$

$= 4180 \times 2 \times 80$

$= \underline{668800 J}$

b) $P = \frac{E}{t}$

$1000 = \frac{E}{900}$

$E = 1000 \times 900$

$= \underline{900000 J}$

c) $E_h = 900000 - 668800$

$= 231200 J$

$E_h = mL$

$231200 = m \times 22.6 \times 10^5$

$m = \frac{231200}{22.6 \times 10^5}$

$= \underline{0.1 kg}$

d) a & c are approximate because heat may have been lost to the surroundings.

8) $P = \frac{E}{t}$

$600 = \frac{E}{60}$

$E = 600 \times 60$
$= 36000J$

$E_h = cm\Delta T$

$36000 = c \times 0{\cdot}2 \times 30$

$c = \frac{36000}{0{\cdot}2 \times 30}$

$= \underline{6000 \text{ J kg}^{-1}\,^{\circ}\text{C}^{-1}}$

9) a) $E_{k\,before} = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 70 \times 900^2$

$= 28350000J$

$E_{k\,after} = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 70 \times 250^2$

$= 2187500J$

$\Delta E_k = 28350000 - 2187500$
$= \underline{26162500J}$

b) $E_h = cm\Delta T$

$26162500 = 980 \times 70 \times \Delta T$

$\Delta T = \frac{26162500}{980 \times 70}$

$= \underline{381^{\circ}C}$

c) Friction between the heat shield and the earth's atmosphere causes the kinetic energy to be transformed into heat energy.

3.6 Gas Laws

Pressure

1) a) 60 cm = 0·6 m A = 0·4 × 0·6 = <u>0·24 m^2</u>
   40 cm = 0·4 m

b) $150 \div 100^2 = 0.015\,m^2$

c) 120 mm = 0·12 m A = 0·12 × 0·15 = 0·018 m^2
   150 mm = 0·15 m

d) $25 \div 1000^2 = 2.5 \times 10^{-5}\,m^2$

e) $0.5 \div 1000^2 = 5 \times 10^{-7}\,m^2$

2) Pressure is the Force applied per m^2 of Area.
Measured in Pascals (Pa)

3)

	Pressure (Pa)	Force (N)	Area (m^2)
a)	75·1	120	1·6
b)	8000	4000	0·5
c)	1.1×10^5	220000	2·0
d)	9000	720	8.0×10^{-2}
e)	12000	7.2×10^5	60
f)	1.4×10^4	4.9×10^4	3·5

4) a) $p = \frac{F}{A}$

$= \frac{240}{4}$

$= 60\,Pa$

b) $p = \frac{F}{A}$

$= \frac{500 \times 10^3}{1.25}$

$= 400\,000\,Pa.$

c) $p = \frac{F}{A}$ $\quad A = 40 \times 25 = 1000\,cm^2$

$\div 100^2$

$= 0.1\,m^2$

$= \frac{125}{0.1}$

$= \underline{1250\,Pa}$

d) $p = \frac{F}{A}$ $\quad A = \pi r^2$

$= \pi \times 12^2$

$= 452\,cm^2$

$\div 100^2$

$= 0.045\,m^2$

$= \frac{64}{0.045}$

$= \underline{1420\,Pa}$

5) $W = mg$

$= 65 \times 9.8$

$= 637\,N$

$p = \frac{F}{A}$

$= \frac{637}{0.025}$

$= \underline{25480\,Pa}$

6) $W = mg$

$= 500 \times 9.8$

$= 4900\,N$

$A = 4 \times 0.1$

$= 0.4\,m^2$

$p = \frac{F}{A}$

$= \frac{4900}{0.4}$

$= \underline{12250\,Pa}$

7) Large tyres distribute the weight of the tractor over a larger area, reducing the pressure exerted on the ground.

8) a) $p = \frac{F}{A}$

$1200 = \frac{F}{2.4}$

$F = 1200 \times 2.4 = \underline{2880\,N}$

b) $p = \frac{F}{A}$

$100000 = \frac{F}{2.4}$

$F = 100000 \times 2.4 = \underline{2.4 \times 10^5}$

c) $p = \frac{F}{A}$

$240\times10^3 = \frac{F}{0.03}$

$A = 25\times12 = 300cm^2$

$\div 100^2$

$= 0.03m^2$

$F = 240\times10^3\times0.03$

$= \underline{7200N}$

d) $p = \frac{F}{A}$

$4.8\times10^7 = \frac{F}{1.6\times10^{-4}}$

$A = 160\ mm^2 = 1.6\times10^{-4}\ m^2$

$F = 4.8\times10^7\times1.6\times10^{-4}$

$= \underline{7680N}$

9) a) $p = \frac{F}{A}$

$960 = \frac{60}{A}$

$A = \frac{60}{960}$

$= \underline{0.063m^2}$

b) $p = \frac{F}{A}$

$840 = \frac{4000}{A}$

$A = \frac{4000}{840}$

$= \underline{4.8m^2}$

c) $p = \frac{F}{A}$

$2.25\times10^7 = \frac{15}{A}$

$A = \frac{15}{2.25\times10^7}$

$= \underline{6.7\times10^{-7}m}$

10) $W = mg$

$= 0.48\times9.8$

$= 4.7N$

$A = \pi r^2$

$= \pi\times0.032^2$

$= 3.2\times10^{-3}m^2$

$p = \frac{F}{A}$

$= \frac{4.7}{3.2\times10^{-3}}$

$= \underline{1470\ Pa}$

11) $p = \frac{F}{A}$

$W = mg$

$= 1250\times9.8$

$= 12250N$

$39\times10^3 = \frac{12250}{A}$

$A = \frac{12250}{39\times10^3} = 0.314\ m^2$

$A_{\text{one tyre}} = \frac{0.314}{4} = \underline{0.079m}$

12) a) $A = 0.93 \times 0.07$

$\doteq 0.065\,m^2$

$W = mg$

$= 30 \times 9.8$

$= 294N$

$p = \frac{F}{A}$

$= \frac{294}{0.065}$

$= 4520\,Pa$

b) $A = 1.24 \times 0.93$

$= 1.15\,m^2$

$p = \frac{F}{A}$

$= \frac{294}{1.15}$

$= 256\,Pa$

13) You are more likely to fall in on your tip toes because you are distributing your weight over a much smaller area, increasing the pressure on the ice.

14) See graph on next page.

Kinetic Theory

1) As more energy is supplied to the liquid the particles within it gain more kinetic energy until they have enough to break away from the other particles nearby.

2) The particles of air inside a tyre are moving and constantly colliding with the walls of the tyre. These collisions provide a Force over the area of the inside of the tyre.

3) a) $25\,cm \times 12\,cm \times 20\,cm = 6000\,cm^3$

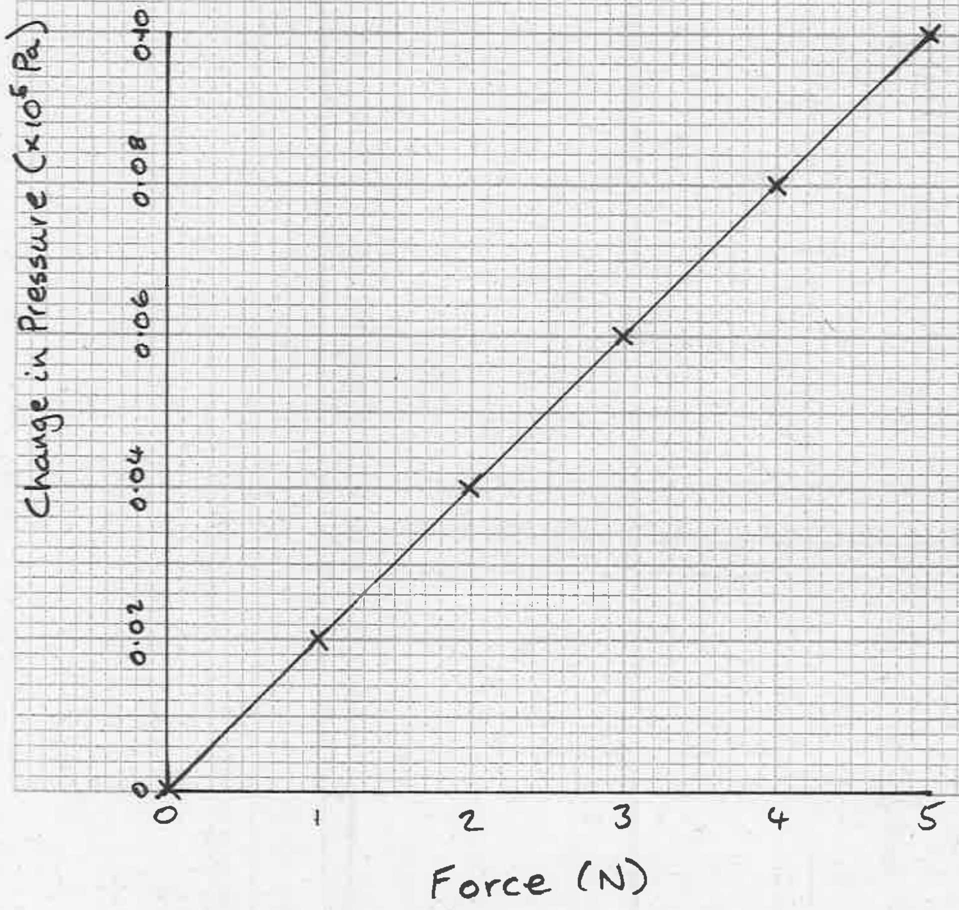
$\div 100^3$

$=$

$0.25\,m \times 0.12\,m \times 0.2\,m = 6 \times 10^{-3}\,m^3$

Pressure

14)



$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{0.1 - 0}{5 - 0}$$

$$= 0.02 = \frac{P}{F} = \frac{1}{A}$$

$$\therefore A = \frac{1}{0.02 \times 10^5}$$

$$= \underline{\underline{5 \times 10^{-4}\ m^2}}$$

b) $480 \div 100^3 = 4.8 \times 10^{-4}\ m^3$

c) $40mm \times 50mm \times 60mm = 120000 mm^3$

$= \quad = \quad = \quad \div 1000^3$

$0.04m \times 0.05m \times 0.06m = 1.2 \times 10^{-4}\ m^3$

d) $25 mm^3 \div 1000^3 = 2.5 \times 10^{-8}\ m^3$

4) a) See graph on next page

b) pressure is inversely proportional to Volume

$p \propto \frac{1}{V} \quad \therefore \quad p = \frac{1}{V} \times \text{constant} \quad \therefore \quad pV = \text{constant}$

c) If a fixed mass of gas is compressed into a smaller volume the particles collide with the walls of the container more often increasing the force over a smaller area, increasing the pressure.

5) As you squeeze a balloon the volume is decreased, this increases the ~~volu~~ pressure until it pops the balloon.

6) a) $p_1 V_1 = p_2 V_2$

$80000 \times 0.48 = 50000 \times V_2$

$V_2 = \frac{80000 \times 0.48}{50000}$

$= 0.77 m^3$

b) $p_1 V_1 = p_2 V_2$

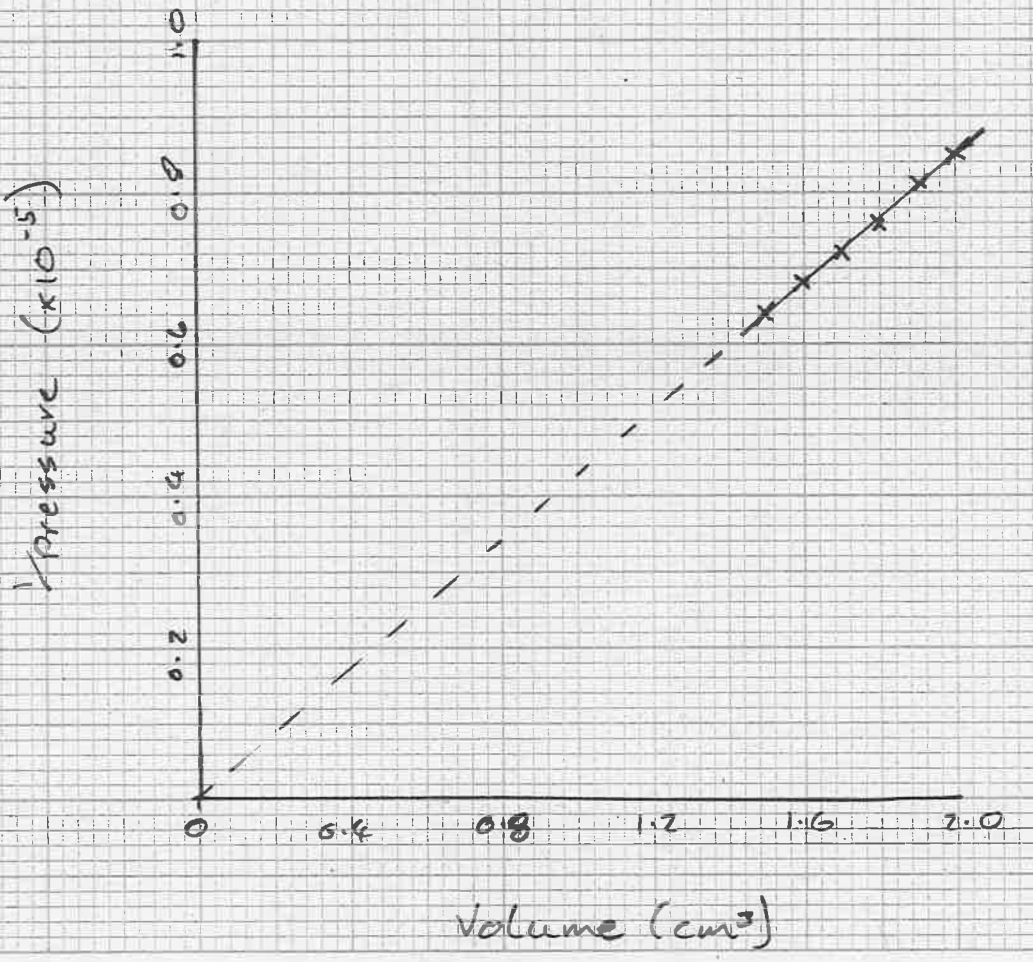
$80000 \times 0.48 = 100000 \times V_2$

$V_2 = \frac{80000 \times 0.48}{100000}$

$= 0.38 m^3$

Kinetic Theory 4) a)

Volume (cm^3)	$1/P \times 10^{-5}$
1.5	0.64
1.6	0.68
1.7	0.72
1.8	0.76
1.9	0.81
2.0	0.85



c) $p_1V_1 = p_2V_2$

$80000 \times 0.48 = 120000 \times V_2$

$V_2 = \frac{80000 \times 0.48}{120000}$

$= \underline{0.32 m^3}$

7) $p_1V_1 = p_2V_2$

$1.01 \times 10^5 \times 5 = p_2 \times 3$

$p_2 = \frac{1.01 \times 10^5 \times 5}{3}$

$= \underline{1.68 \times 10^5 \text{ Pa}}$

8) $p_1V_1 = p_2V_2$

$120000 \times 2.4 = p_2 \times 2.0$

$p_2 = \frac{120000 \times 2.4}{2.0}$

$= \underline{144000 \text{ Pa}}$

9) $p_1V_1 = p_2V_2$

$105000 \times 60 = 140000 \times V_2$

$V_2 = \frac{105000 \times 60}{140000}$

$= \underline{45 m^3}$

10) a) $p_1V_1 = p_2V_2$

$100000 \times 60 = p_2 \times 8 \times 10^{-5}$

$p_2 = \frac{100000 \times 60}{8 \times 10^{-5}}$

$= \underline{7.5 \times 10^{10} \text{ Pa}}$

b) $p_1V_1 = p_2V_2$

$100000 \times 60 = p_2 \times 1.5 \times 10^{-4}$

$p_2 = \frac{100000 \times 60}{1.5 \times 10^{-4}}$

$= \underline{4 \times 10^{10} \text{ Pa}}$

c) $p_1 V_1 = p_2 V_2$

$100000 \times 60 = p_2 \times 2 \times 10^{-4}$

$p_2 = \frac{100000 \times 60}{2 \times 10^{-4}}$

$= \underline{3 \times 10^{10} \text{ Pa}}$

11) $V = \frac{4}{3} \pi r^3$

$= \frac{4}{3} \pi \times 0.04^3$

$= 2.7 \times 10^{-4} \text{ m}^3$

$p_1 V_1 = p_2 V_2$

$500000 \times 2.7 \times 10^{-4} = 100000 \times V_2$

$V_2 = \frac{500000 \times 2.7 \times 10^{-4}}{100000}$

$= 1.35 \times 10^{-3} \text{ m}^3$

$r = \sqrt[3]{\frac{3}{4} \frac{V}{\pi}}$

$= \sqrt[3]{\frac{3}{4} \frac{1.35 \times 10^{-3}}{\pi}}$

$= \underline{0.069 \text{ m}}$

12) a) 20°C = 293 K b) 27°C = 300 K c) 120°C = 393 K
d) −53°C = 220 K

13) a) 353 K = 80°C b) 300 K = 27°C c) 200 K = −73°C
d) 60 K = −213°C

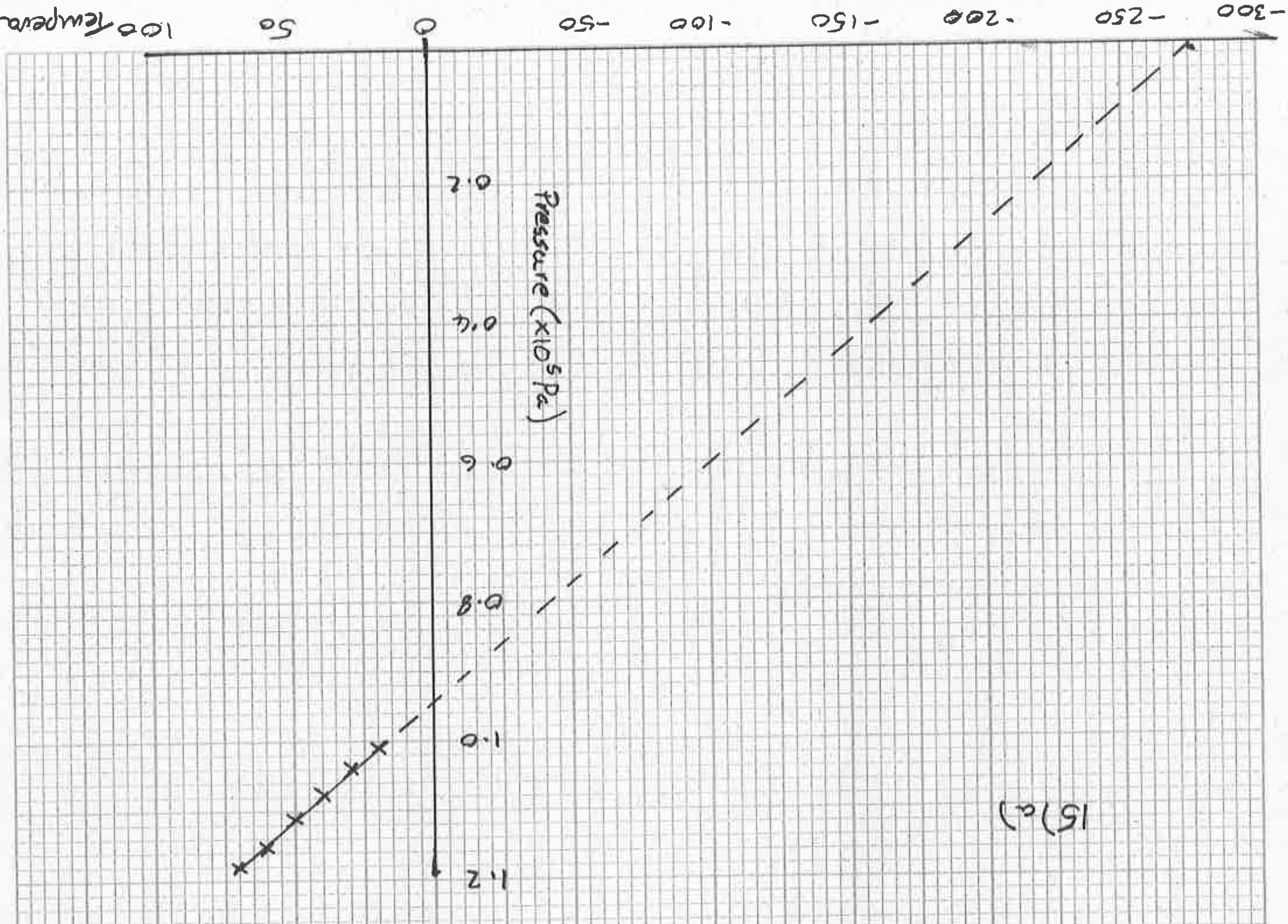
14) $\Delta T = 170 \text{ K} = 170°\text{C}$

15) a) See graph on next page.

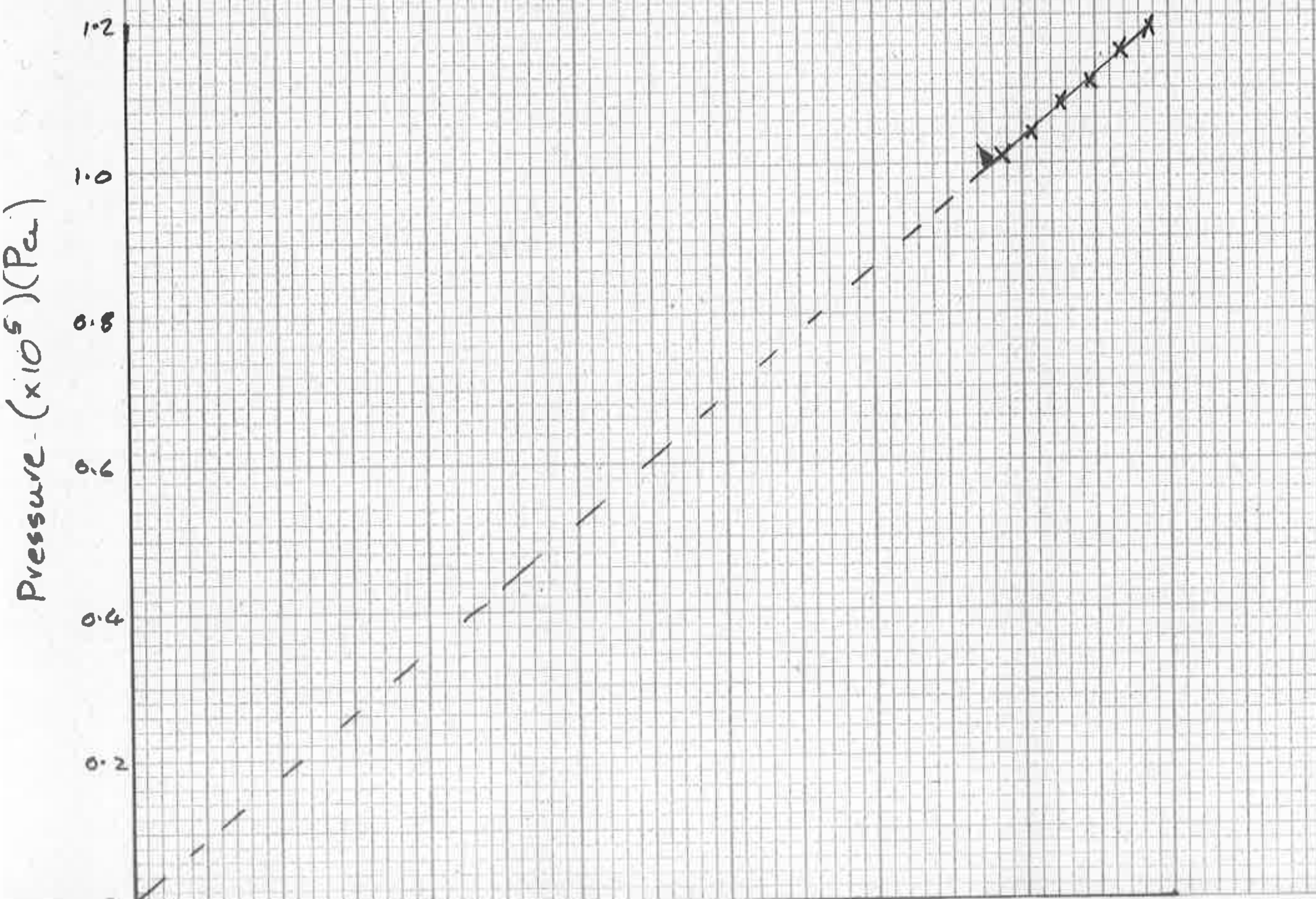
b) −275°C ± 2°C

c) See graph on next page.

d) Temperature and pressure are directly proportional.



15)c)



°C	K
20	293
30	303
40	313
50	323
60	333
70	343

e) As the temperature increases the particles in the gas move faster so they collide with cotainer more often and with a greater force, increasing the pressure.

16) If you overfill tyres when they heat up through friction with the road the pressure will increase to the point they damage the tyre.

17) a) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{120000}{300} = \frac{P_2}{350}$

$P_2 = \frac{120000 \times 350}{300}$

$= \underline{140000\ Pa}$

b) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{120000}{300} = \frac{P_2}{327}$

$P_2 = \frac{120000 \times 327}{300}$

$= \underline{131000\ Pa}$

c) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{120000}{300} = \frac{P_2}{375}$

$P_2 = \frac{120000 \times 375}{300}$

$= \underline{150000\ Pa}$

d) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{120000}{300} = \frac{P_2}{250}$

$P_2 = \frac{120000 \times 250}{300}$

$= \underline{100000\ Pa}$

18) a) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{132000}{360} = \frac{120000}{T_2}$

$T_2 = \frac{120000 \times 360}{132000}$

$= 327\ K = \underline{54^\circ C}$

b) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{132000}{360} = \frac{66000}{T_2}$

$T_2 = \frac{66000 \times 360}{132000}$

$= 180\ K = \underline{-93^\circ C}$

c) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{132000}{360} = \frac{200000}{T_2}$

$T_2 = \frac{200000 \times 360}{132000}$

$= 545K = \underline{272°C}$

19) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{225}{310} = \frac{232}{T_2}$

$T_2 = \frac{232 \times 310}{225}$

$= \underline{320K}$

20) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{207}{423} = \frac{232}{T_2}$

$T_2 = \frac{232 \times 423}{207}$

$= \underline{474K}$

21) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{2.5 \times 10^3}{315} = \frac{P_2}{298}$

$P_2 = \frac{2.5 \times 10^3 \times 298}{315}$

$= \underline{2370 Pa}$

22) At absolute zero the particles have zero kinetic energy, they can not have any less.

23) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{104 \times 10^3}{293} = \frac{P_2}{363}$

$P_2 = \frac{104 \times 10^3 \times 363}{293}$

$= \underline{129 \times 10^3 \text{ Pa}}$

24) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{2.41 \times 10^5}{283} = \frac{2.58 \times 10^5}{T_2}$

$T_2 = \frac{2.58 \times 10^5 \times 283}{2.41 \times 10^5}$

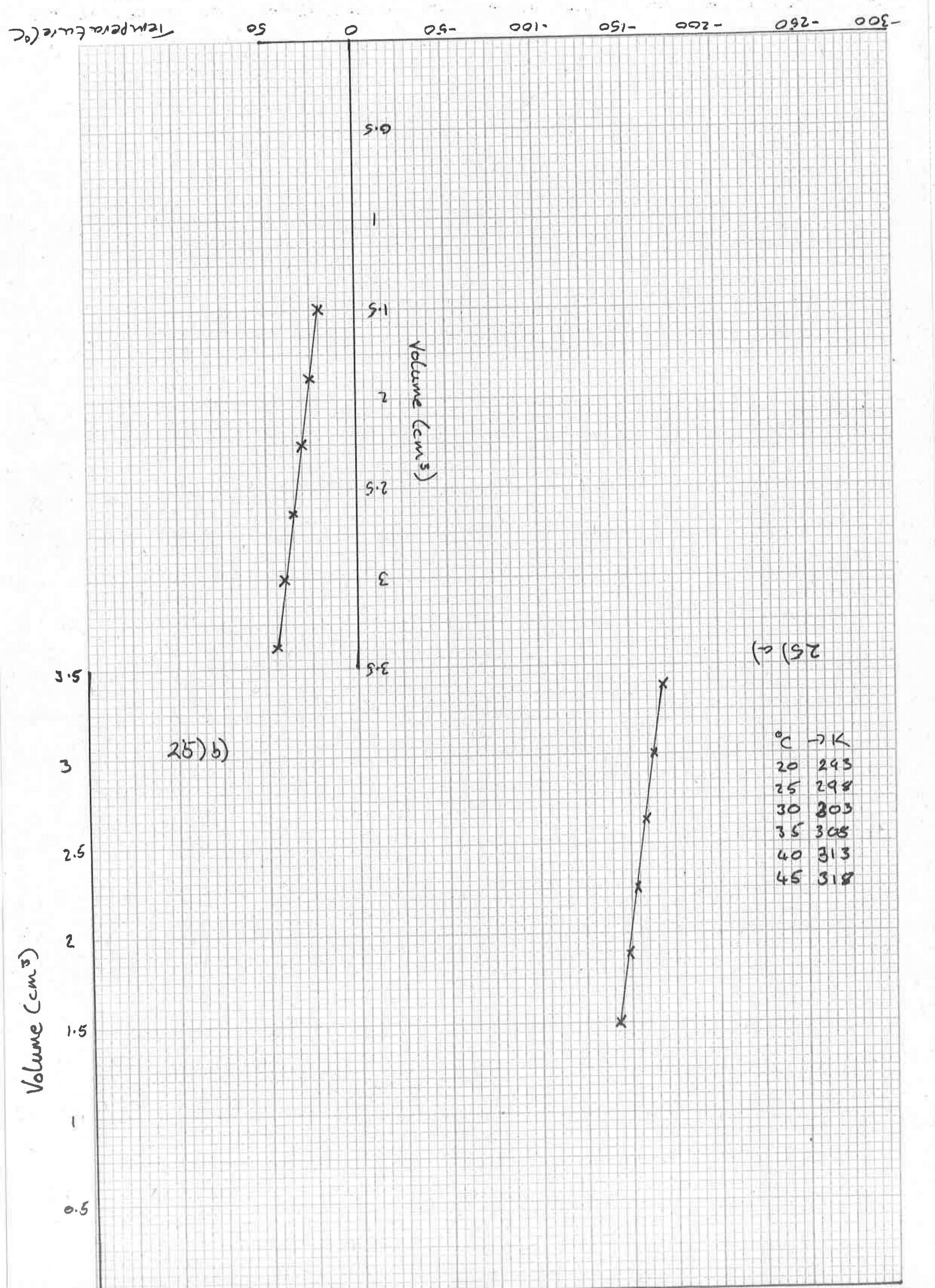
$= 303\text{K} = \underline{30^\circ\text{C}}$

25) a) See graph on next page

b) See graph on next page

c) Temperature and volume of a graph are directly proportional. $T \propto V$

d) As the temperature of the gas increases the particles move faster so they collide with the container more often with greater force increasing its volume.



Temperature (°C)
50
0
-50
-100
-150
-200
-250
-300
Volume (cm³)
0.5
1
1.5
2
2.5
3
3.5
25) b)
25) c)
°C → K
20 293
25 298
30 303
35 308
40 313
45 318

26) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{0.15}{300} = \frac{V_2}{360}$

$V_2 = \frac{0.15 \times 360}{300}$

$= 0.18 cm^3$

27) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{100}{273} = \frac{110}{T_2}$

$T_2 = \frac{110 \times 273}{100}$

$= 300 K$

28) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{0.1}{300} = \frac{V_2}{360}$

$V_2 = \frac{0.1 \times 360}{300}$

$= 0.12 cm^3$

29) The ~~pressu~~ volume doesn't double because it is directly proportiona to the temperature in Kelvin not °C. 20°C → 48C = 293K → 313K.

30) a) The volume is directly proportional to the temperatu in Kelvin which has not doubled 303K → 333K

b) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{30}{303} = \frac{V_2}{333}$

$V_2 = \frac{30 \times 333}{303}$

$= 33 cm^3$

31) $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

$\frac{1.63 \times 10^5 \times 3}{295} = \frac{p_2 \times 5}{330}$

$p_2 = \frac{1.63 \times 10^5 \times 3 \times 330}{295 \times 5} = 1.09 \times 10^5 Pa$

32) $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

$\frac{116000 \times 4.8 \times 10^{-6}}{280} = \frac{p_2 \times 3.2 \times 10^{-6}}{294}$

$p_2 = \frac{116000 \times 4.8 \times 10^{-6} \times 294}{280 \times 3.2 \times 10^{-6}}$

$= \underline{182700 \text{ Pa}}$

33) $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

$\frac{108000 \times V_1}{296} = \frac{96000 \times 9.6}{333}$

$V_1 = \frac{96000 \times 9.6 \times 296}{333 \times 108000}$

$= \underline{7.6 \text{ cm}^3}$

34) $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

$\frac{100000 \times 100}{300} = \frac{p_2 \times 20}{277}$

$p_2 = \frac{100000 \times 100 \times 277}{300 \times 20}$

$= \underline{4.6 \times 10^5 \text{ Pa}}$

35) a) As the temperature decrease the particles of gas lose kinetic energy, they move more slowly so impact with the container less often and with less force, decreasing the pressure.

b) As the volume increases the particles of the gas collide with the container less often over a greater area. Decreasing the pressure.