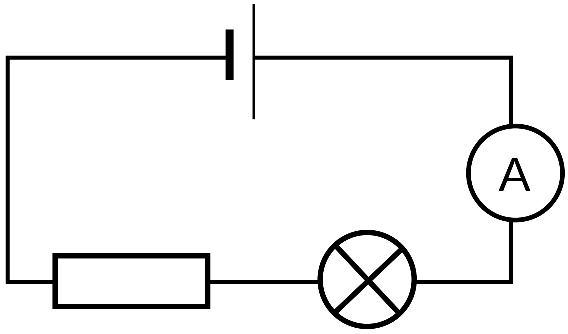
Electrical charge carriers and electric fields

Electric charge

1. Electrons

2. Ammeter can be placed anywhere in series in the circuit.



3. Q = It

4. (*a*) 40 C
(*b*) 1 C
(*c*) 3000 s
(*d*) 80 s
(*e*) 0·05 A
(*f*) 0·05 A

5. 20 C

6. (*a*) 5 C
(*b*) $3{\cdot}125 \times 10^{19}$

7. 3 A

8. 1000 s

a.c. and d.c.

9. a.c. - mains d.c. – cell or battery.

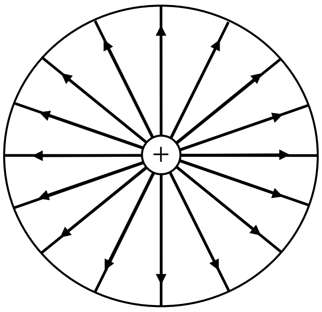
10. 50 Hz

11. Trace 1 is a.c. and trace 2 is d.c.

12. An object can have either negative or positive charge. Electrons have **negative** charge, When a charged object is placed in an electric field, its movement will depend upon its **charge**. A positive charge will be repelled by a **positive** charge whilst a negative charge will be **attracted**.

In a circuit, it is electrons which flow around the circuit. The energy for them to move comes from a **potential** difference or **voltage**. Electrons will flow towards the **positive** connection of a power supply and away from the **negative** connection. The size of the potential difference or voltage is a measure of the **energy** given to the electrons.

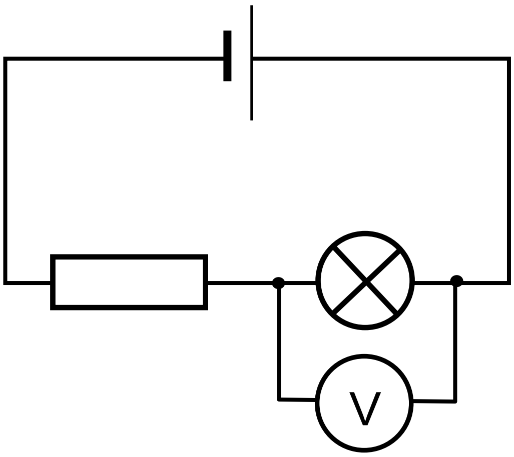
13.



14. **A.** It would be attracted to the dome.
B. It would be repelled away from the dome.

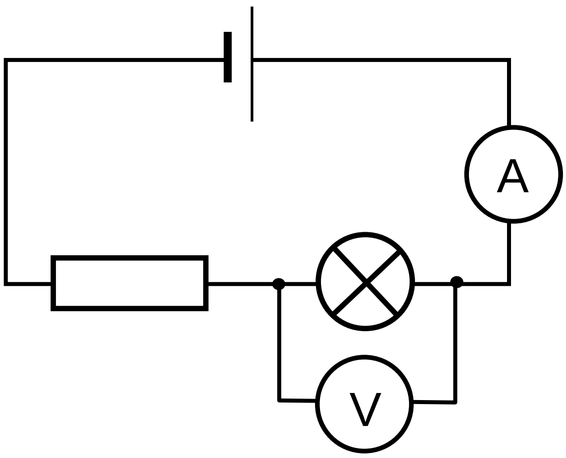
15. (*a*) The hair picks up the same charge as the dome. As like charges repel, the air strands are repelled from one another.
(*b*) If he stood on the ground the charge would flow to earth and he would not become charged.

16.



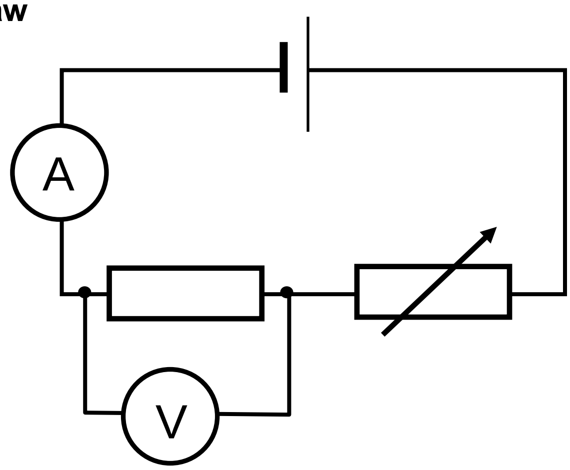
17. (*a*) Switch
(*b*) Connected wires
(*c*) Cell
(*d*) Battery
(*e*) Voltmeter
(*f*) Ammeter
(*g*) Ohmmeter
(*h*) Resistor
(*i*) Variable resistor
(*j*) Lamp
(*k*) Fuse
(*l*) Motor

18. (*a*) Cell, connecting wire, resistor, lamp.
(*b*) Ammeter can be anywhere in circuit as long as it is in series with the lamp.



Ohm's Law

19. (*a*)



(*b*) Current will decrease.
(*c*) (i) Resistance will decrease.
(ii) Current will increase.

20. (*a*) It will reduce the error caused by poor readings.

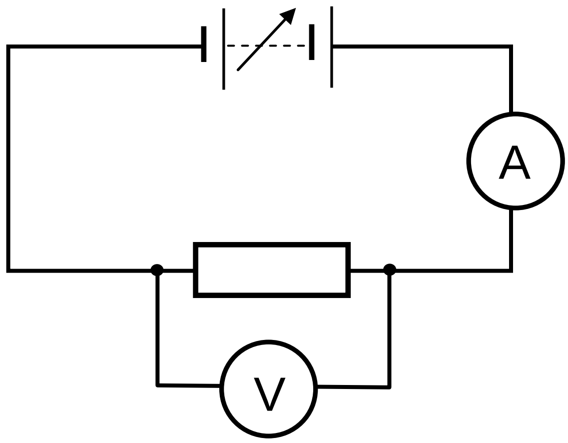
(*b*) Different lengths of wire would have different resistances.

(*c*) (i)

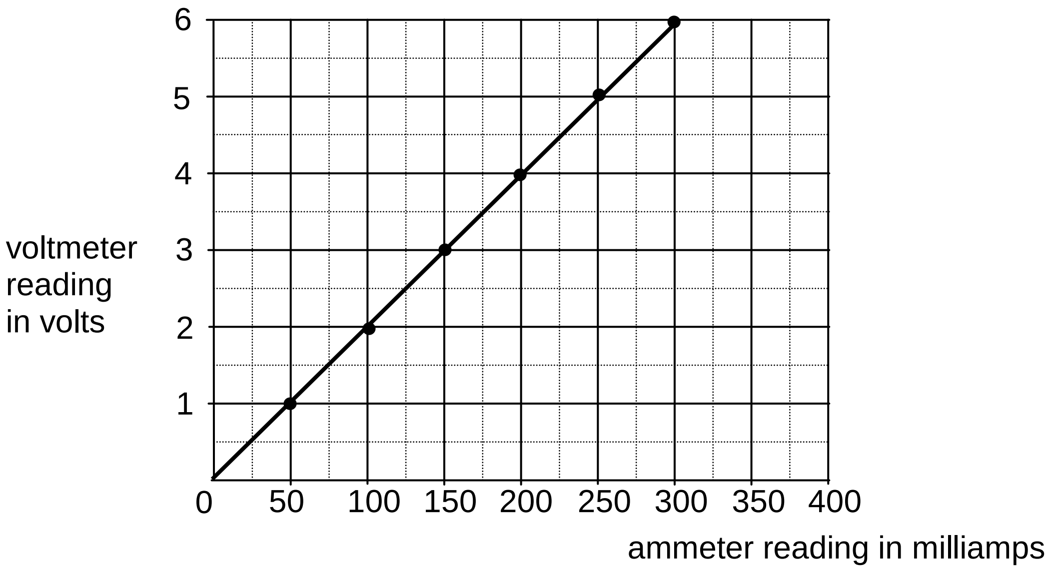
Voltage in volts, V	2	4	6	8	10	12
Current in amps, I	0·25	0·5	0·75	1·0	1·25	1·5
V/I	8·0	8·0	8·0	8·0	8·0	8·0

(ii) The wire has a resistance of 8·0 Ω.

21. (*a*)



(*b*) 20 Ω



22. V = IR

23. (*a*) 10 V
(*b*) 60 V
(*c*) 28·75 Ω
(*d*) 600 Ω
(*e*) 0·46 A
(*f*) 0·2 A

24. Current increases.

25. 46 Ω

26. 0·042 A

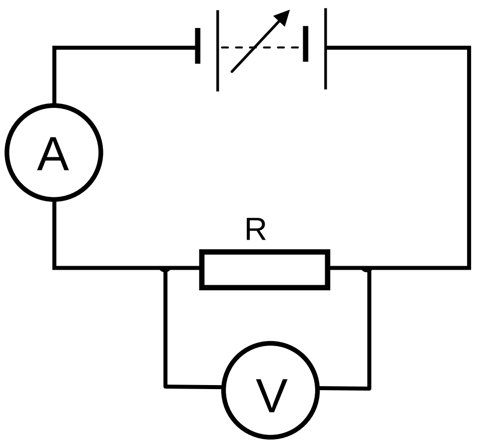
27. 228 V

28. 1 mA

29. 6 Ω

30. (*a*) 0·23 A
(*b*) (i) Resistance has increased as the filament became hotter.
(ii) 3·6 A
(*c*) This is when the current through the filament is highest.

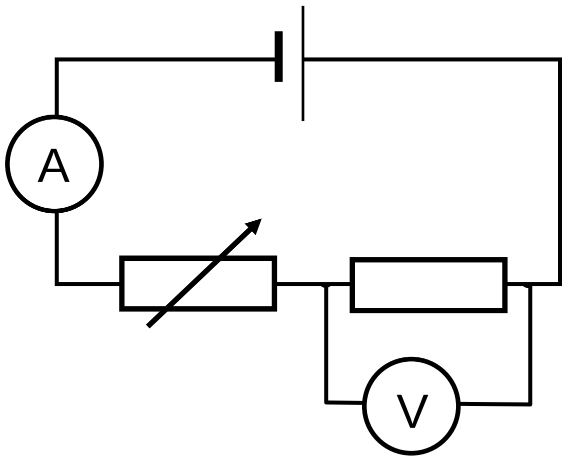
31. (*a*)



(*b*) (i) 2·0 A
(ii) 2 Ω

32. Voltmeter reading = 1·5 V, ammeter reading = 1 x 10^{-3} A or 1 mA.

33. (*a*) The current will be the same.
(*b*)



(*c*) 15 Ω
(*d*) Ammeter reading will decrease.

34. Series (*a*) and (*d*) Parallel (*b*), (*c*) and (*e*). (*f*) is a mixture of series and parallel.

35. (*a*) A_1 = 3 A, A_2 = 3 A
(*b*) A_3 = 3 A
(c) A_4 = 9 A, A_5 = 2 A
(*d*) V_1 = 9 V , V_2 = 9 V
(e) A_6 = 4 A, A_7 = 4 A
(*f*) V_3 = 2 V

Resistors in series and parallel

36. $R_{total} = R_1 + R_2 + R_3$

37. $$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

38. (*a*) 15 Ω
(*b*) 6 kΩ
(*c*) 20 kΩ
(*d*) 13 Ω
(*e*) 40 kΩ
(*f*) 5 kΩ
(*g*) 800 Ω
(*h*) 18 Ω

39. (*a*) 2·5 Ω
(*b*) 3·3 Ω
(*c*) 10 Ω
(*d*) 6·86 Ω
(*e*) 2·5 Ω
(*f*) 66·7 Ω
(*g*) 2 Ω
(*h*) 1·25 kΩ

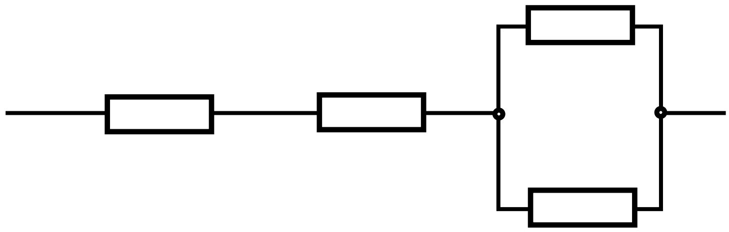
40. (*a*) 10 Ω
(*b*) 4 Ω
(*c*) 12 Ω
(*d*) 5 Ω
(*e*) 15 Ω
(*f*) 40 Ω
(*g*) 11·6 Ω
(*h*) 3 Ω

41. (*a*) 15 Ω
(*b*) 0·6 A
(*c*) (i) 3 V
(ii) 6 V

42. (*a*) 2·5 Ω
(*b*) 12 V
(*c*) 12 V
(*d*) 12 V
(*e*) (i) 0·6 A
(ii) 1·2 A

Extension Questions

43. (*a*) (i) 3 Ω
(ii) 57 – 63 Ω
(*b*) (i) R_1 = 66·7 Ω, R_2 = 57·1 Ω
(ii) R_1 is outside the allowable range, R_2 is within the allowable range.
(*c*) 20 Ω
(*d*)



44. (*a*) (i) 5 Ω
(ii) 2·4 A
(iii) The current will decrease as the total resistance of the circuit will increase, no matter which resistor fails.
(*b*) It will not work as all the voltmeters will read 12 V, even across the faulty resistor.

45. (*a*) 9 V
(*b*) 5 V
(*c*) 18 Ω
(*d*) 0·5 A
(*e*) 6 Ω

46. (*a*) B
(*b*) A
(*c*) B
(*d*) A
(*e*) B
(*f*) A
(*g*) B

47. (*a*) V_1 = 5 V , V_2 = 0 V
(*b*) V_3 = 0 V , V_4 = 3 V
(*c*) V_5 = 6 V , V_6 = 0 V

48. (*a*) 3·6 V
(*b*) 1 V
(*c*) 5·14 V

Electronic circuits

49. (*a*) Capacitor
(*b*) Thermistor
(*c*) Light dependant resistor (LDR)
(*d*) Diode
(*e*) Light emitting diode (LED)
(*f*) Photo voltaic cell
(*g*) Motor
(*h*) Loudspeaker
(*i*) Transistor
(*j*) Relay

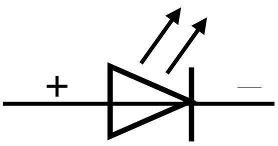
50.

Device	*Input device*	*Output device*
(*a*) loudspeaker		✓
(*b*) capacitor	✓	
(*c*) LED		✓
(*d*) LDR		✓
(*e*) thermistor	✓	
(*f*) relay		✓

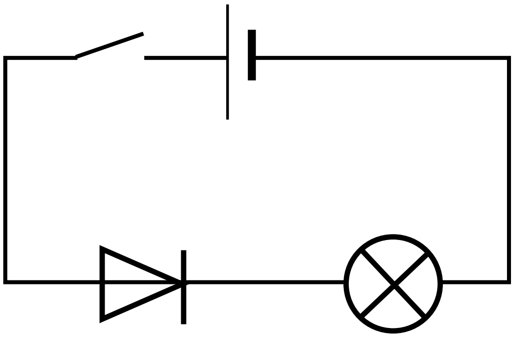
51.

Device	*Input energy*	*Output energy*
(*a*) loudspeaker	electrical	sound
(*b*) LED	electrical	light
(*c*) LDR	light	electrical
(*d*) thermistor	heat	electrical
(*e*) relay	electrical	kinetic
(*f*) motor	electrical	kinetic
(*g*) photovoltaic cell	light	electrical

52.



53.



54. LED 2, LED 4

55. A capacitor will store charge. When fully charged it will have a voltage across it equal to the charging voltage.

56. (*a*) (i) 12 V
(ii) 0 V
(*b*) (i) It will take longer.
(ii) No effect.
(iii) No effect.

57. A resistor will normally have a resistance which **does not change**. The resistance of some devices will change according to certain factors. The resistance of a thermistor changes with **temperature**. For most thermistors, as the temperature increases its resistance **decreases**. LDRs change their **resistance** with changing levels of light. As the light levels decrease, the resistance of the LDR **increases**.

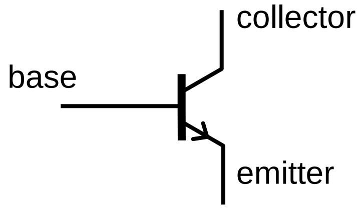
58. (*a*) Thermistor
(*b*) 8 V
(*c*) 4 V
(*d*) 2 kΩ
(*e*) (i) No change.
(ii) Current increases.

59. (*a*) 2 V
(*b*) 1 V
(*c*) 8 V

60. (*a*) Light dependent resistor
(*b*) 3 V
(*c*) 6 V
(*d*) 200 Ω
(*e*) Current increases.

61. (*a*) 4 V
(*b*) 4 V
(*c*) 2 V
(*d*) 1 V
(*e*) 4 V

62.



63. 1. True
2. False
3. True
4. False
5. True
6. True
7. False

64. (*a*) Yes
(*b*) No
(*c*) Yes
(*d*) Yes
(*e*) Yes
(*f*) Yes

65. (*a*) MOSFET transistor.
(*b*) g – gate, d – drain, s – source.

66. 1. True
2. False
3. False
4. True
5. True
6. True
7. False

67. (*a*) Yes
(*b*) Yes
(*c*) No
(*d*) Yes

68. (*a*) In the dark.
(*b*) 0·7 V
(*c*) Resistance of LDR falls and so the voltage across it falls, switching off the transistor.

69. (*a*) It will decrease.
(*b*) (i) The voltage will decrease.
(ii) It will increase.
(*c*) The transistor will be switched on.
(*d*) By adjusting the variable resistor.

Extension Questions

70. (*a*) X - Variable resistor
Y - Light dependent resistor
Z - Transistor
(*b*) (i) The resistance will increase.
(ii) The voltage will increase.
(iii) The transistor will be switched on and the LEDs will light.
(*c*) They would not light.

71. (*a*) As the temperature of the thermistor rises the voltage across it increases. This switches on the MOSFEt transistor when it is over 2 V. There will now be a voltage across the relay which switches on the warning lamp connected to the mains.
(*b*) it operates at low voltage whilst the lamp operates at mains voltage.

72. (*a*) X - Variable resistor
Y - Light dependent resistor
Z - Relay
(*b*) As it gets dark the resistance of the LDR increases. This increases the voltage across it which switches on the transistor. The transistor switches on the relay which turns on the security light.
(*c*) Alter the value of the variable resistor.
(*d*) It operates at 5 V and not mains voltage. The transistor cannot supply a large current. The transistor operates on a d.c. supply and the security light an a.c. supply.

Electrical Power

73. (*a*) Food mixer - Electrical energy into kinetic energy
Iron - Electrical energy into heat energy
Light bulb - Electrical energy into heat and light energy
(*b*) Food mixer - Approximately 400 W
Iron - Approximately 1000 W
Light bulb - Approximately 60 W

74. (*a*) Electric oven, curling tongs, television, table lamp, radio.
(*b*) Electric oven - 8000 W, curling tongs - 750 W, television - 300 W, table lamp - 60 W, radio - 10 W.
(*c*) They produce heat.

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

76. (*a*) 10 W
(*b*) 1000 W
(*c*) 100 s
(*d*) 60 s
(*e*) 1000 J
(*f*) 360 000 J

77. 2 W

78. 30 s

79. 800 W

80. (*a*) 1 080 000 J
(*b*) This is when the washing machine is heating the water.

81. P = IV

82. (*a*) 690 W
(*b*) 6 W
(*c*) 230 V
(*d*) 12 V
(*e*) 10·87 A
(*f*) 167 mA

83. 460 W

84. 1380 W

85. 4·2 A

86. 6 V

87. (*a*) 5·2 A
(*b*) The heater.

88. $P = I^2R$

89. (*a*) 270 W
(*b*) 15 W
(*c*) 32 Ω
(*d*) 2·4 Ω
(*e*) 3 A
(*f*) 0·5 A

90. 920 W

91. 4 A

92. 0·036 W

93. 0·07 A

94. (*a*) 4 A
(*b*) 57·5 Ω

95. $P = \frac{V^2}{R}$

96. (*a*) 1322 W
(*b*) 14·4 W
(*c*) 10 Ω
(*d*) 882 Ω
(*e*) 100 V
(*f*) 10 V

97. 1058 Ω

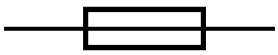
98. 24 Ω

99. 48 W

100. 4 Ω

Fuses

101.



102. The fuse prevents too large a current flowing through flex to the appliance and causing it to overheat.

103. A large current might flow to the appliance overheating the flex and the fuse not blow. This could cause a fire.

104. (*a*) (i) 0·26 A, 3 A fuse
(ii) 8·7 A, 13 A fuse
(iii) 3·5 A, 5 A fuse
(iv) 2·2 A, 3 A fuse
(*b*) The normal current exceeds 3 A at 3·7 A.

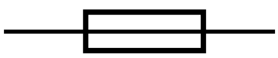
Extension Questions

105. (*a*) 2·4 W
(*b*) Heat energy

106. (*a*) 230 V
(*b*) 26.45 Ω

107. (*a*) 10350 W
(*b*) 30·4 A
(*c*) It requires a greater current than the 13 A a socket can supply.

108. (*a*)



(*b*) (i) 20 A
(ii) 84 W

109. (*a*) 9·6 A, use a 10 or 13 A fuse
(*b*) 24 Ω

Conservation of energy

110. Energy can neither be created or destroyed, only changed from one form to another.

111. (*a*) Kinetic energy into kinetic energy.
(*b*) Some energy lost as heat and sound.

112. (*a*) (i) Potential energy into kinetic energy.
(ii) Kinetic energy into electrical energy.
(*b*) (i) Friction as water flows through pipes.
(ii) electrical losses in generator and friction between moving parts.

Potential energy

113. E_p = mgh

114. (*a*) 588 J
(*b*) 24·5 J
(*c*) 20 m
(*d*) 40 m
(*e*) 5 kg
(*f*) 1 kg

115. 470·4 J

116. 6·25 m

117. 50 kg

118. (*a*) 11.76 J
(*b*) 1·92 J

Kinetic energy

119. $E_k = ½m \times v^2$

120. A lorry is used to collect waste from houses for recycling.
(*a*) Its E_k increases as the mass of the lorry increases.
(*b*) E_k increases.

121. (*a*) 16 J
(*b*) 10 J
(*c*) 2·8 m s^{-1}
(*d*) 5 m s^{-1}
(*e*) 800 kg
(*f*) 10 kg

122. $4·05 \times 10^8$ J

123. 122·5 J

124. 600 kg

125. (*a*) 3 m s^{-1}
(*b*) The potential energy of the ball.

126. (*a*) 225 J
(*b*) It is converted into heat due to friction.

Potential and kinetic energy transfer

127. (*a*) 14·7 J
(*b*) 7·7 m s^{-1}

128. (*a*) 0·39 J
(*b*) 0·39 J
(*c*) The swing losses energy due to air resistance and friction.

129. (*a*) 4320 J
(*b*) 7·3 m

Extension Questions

130. (*a*) 9·6 J
(*b*) (i) 3·3 m
(ii) There are energy losses due to air resistance.

131. 5·4 m s^{-1}

132. (*a*) 294 J
(*b*) (i) 294 J
(ii) 5·4 m s^{-1}
(*c*) There are energy losses due to air resistance and friction.

Pressure, force and area

133. The downward force from the Eskimo’s weight is spread over a larger area which reduces the pressure under his feet.

134. A sharp knife will have a smaller area at the edge of the blade meaning the pressure under the blade is greater.

135. The heel of the shoe has a very small area compared to a normal shoe. This means the ladies weight is spread over a very small area which increases the pressure under her heel.

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

137. (*a*) 25 Pa
(*b*) 40 Pa
(*c*) 0·015 m^2
(*d*) 0·01 m^2
(*e*) 10 000 N
(*f*) 20 000 N

138. 667 Pa

139. 4000 N

140. (*a*) 1×10^8 Pa

(*b*) The small surface area of the pin point means that there will be a large pressure under it for any given force.

Extension Questions

141. Estimated area of foot in contact with ground approximately
$5\ cm^2 = 2{\cdot}5 \times 10^{-3}\ m^2$
Pressure = $1{\cdot}8 \times 10^5$ Pa

Pressure and volume

142. (*a*) Temperature.

(*b*) $p \propto \frac{1}{V}$

143. $p_1V_1 = p_2V_2$

144. (*a*) $1{\cdot}25 \times 10^4$ Pa

(*b*) 2×10^7 Pa

(*c*) $1{\cdot}67 \times 10^{-3}\ m^3$

(*d*) 80 litres

(*e*) $2{\cdot}5 \times 10^5$ Pa

(*f*) 10×10^5 Pa

(*g*) $5\ m^3$

(*h*) 0·07 litres

145. $0{\cdot}03\ m^3$

146. (*a*) The surrounding water pressure decreases as the bubbles rise allowing them to expand.

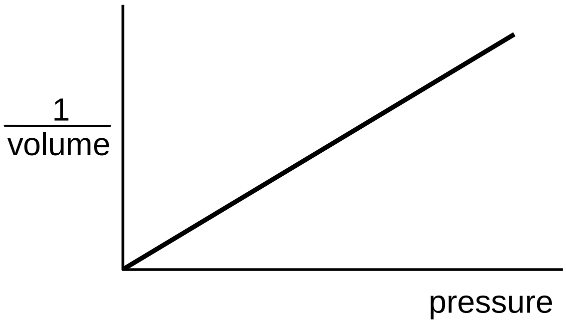
(*b*) $8 \times 10^{-6}\ m^3$

147. $0{\cdot}006\ m^3$

148. (*a*)

Pressure in kPa	***Volume in cm³***	***1/Volume***
100	14·7	0·068
150	9·9	0·101
200	7·4	0·135
250	5·9	0·169
300	4·9	0·204

(*b*)



(*c*) 735 kPa

Kelvin scale

149. (*a*) 20 K
(*b*) –273 °C

150. (*a*) 273 K
(*b*) 300 K
(*c*) 400 K
(*d*) 0 K
(*e*) 100 K
(*f*) 350 K
(*g*) 146 K
(*h*) 619 K
(*i*) 291 K
(*j*) 373 K

151. (*a*) –273 °C
(*b*) 0 °C
(*c*) 20 °C
(*d*) 27 °C
(*e*) 100 °C
(*f*) –100 °C
(*g*) 50 °C
(*h*) –223 °C
(*i*) 350 °C
(*j*) 177 °C

152. Absolute zero is the lowest achievable temperature where the kinetic energy of the molecules making up a gas will be zero.

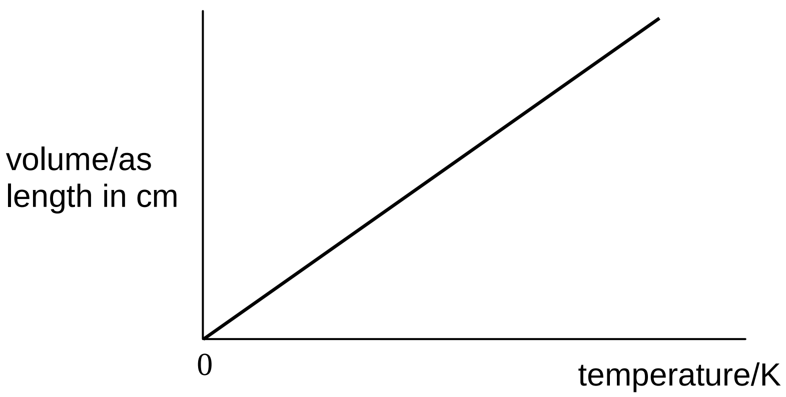
153. 0 K and –273 °C

Volume and temperature

154. (*a*)

Temperature in °C	***Temperature in K***	***Volume (length of air column)***
20	293	21·5
40	313	22·9
60	333	24·4
80	353	25·9
100	373	27·3

(*b*)



$V \propto T$ when temperature is in Kelvin

(*c*) Have more of the tube under water. The water could also be stirred to create an even temperature in the water and give time for the temperature to stabilise between readings.

(*d*) 19·3

155. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ providing T is in kelvin

156. (*a*) 800 K

(*b*) 12 litres

(*c*) 0·028 m^3

(*d*) 50 K

(*e*) 1200 K (927 °C)

(*f*) 2·07 m^3

(*g*) 2·5 m^3

(*h*) 40 K (–233 °C)

157. (*a*) 300 K
(*b*) 23·3 cm^3

158. 20 litres

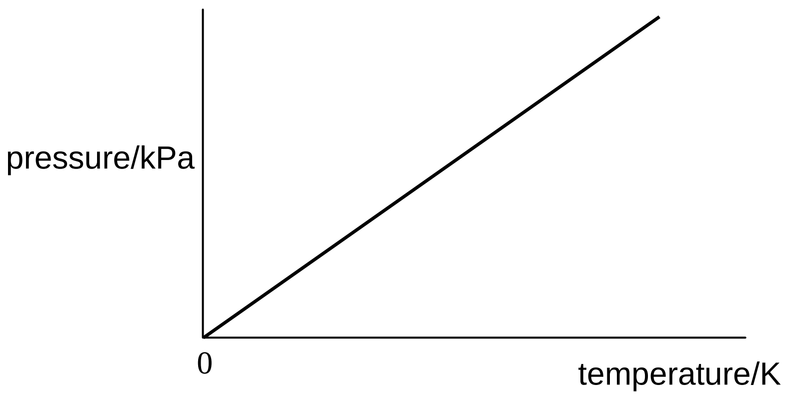
159. 1·67 m^3

Pressure and temperature

160. (*a*)

Temperature in °C	***Temperature in K***	***Pressure in kPa***
10	283	100
20	293	104
30	303	107
40	313	111
50	323	114
60	333	118

(*b*)



$P \propto T$ when temperature is in Kelvin

(*c*) The mass of gas in the flask and its volume.
(*d*) Have the flask totally under the water and have the pressure gauge as close as possible to the flask.

161. $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ *providing* T *is in kelvin*

162. (*a*) 600 K
(*b*) 300 kPa
(*c*) 7 × 10^5 Pa
(*d*) 333 K
(*e*) 1200 K (927 °C)
(*f*) 1·38 × 10^5 Pa
(*g*) 75 kPa
(*h*) 75 K (–198 °C)

163. $3 \cdot 6 \times 10^5$ Pa

164. 120 kPa

165. 117 kPa

166. 540 K (267 °C)

Kinetic model

167. A. False
B. False
C. False
D. True
E. False
F. True

168. (*a*) They produce an outwards force on the container walls.
(*b*) The particles will move faster.
(*c*) (i) The pressure increases.
(ii) The gas particles move faster and collide with the container walls more often and with greater kinetic energy. They hit the walls of the container harder and produce a greater outwards force.

169. Gas particles in the container slow down when it is cooled. They collide with the container walls less often and with less force so decreasing the gas pressure in the canister.

170. (*a*) It will be greater.
(*b*) The balloon expands will the pressure inside and outside are the same.

171. The gas particles collide with the walls of the container. This produces an outwards force on the container wall causing the pressure.

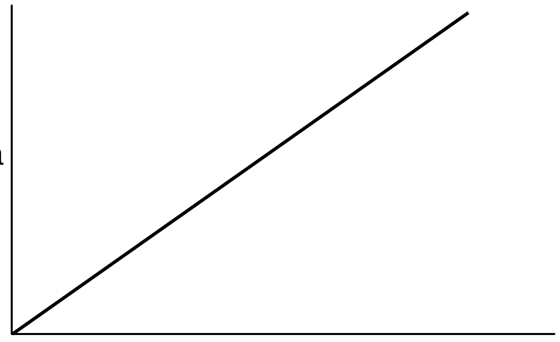
172. The increased mass of gas in the tyre means there are more air particles colliding with the walls of the tyre so creating a greater pressure.

173. The removal of air from the can means there are less gas particles colliding with the wall of the can compared to the air particles outside the can. This means there is a pressure pushing the can sides inwards.

174. The gas particles gain more kinetic energy as the temperature of the gas rises. This means they hit the container walls more often and with greater force so increasing the pressure.

175. (*a*) $0 \cdot 75$ m^3
(*b*) The air in her lungs expands as the pressure decreases as her depth reduces.

176. (*a*)



(*b*) Gas particles have more kinetic energy as the temperature of the gas increases. This means they hit the container walls more often and with greater force so increasing the pressure.

(*c*) $3{\cdot}7 \times 10^5$ Pa

177. (*a*) 225 cm^3

(*b*) As the pressure in the aircraft cabin decreases there are more collisions by gas particles with the Pringles container on the inside than on the outside. This causes an outwards pressure on the carton.

178. (*a*) 12 litres

(*b*) $2{\cdot}1 \times 10^{-7}$ m^3

(*c*) 0·42 litres

Specific Heat Capacity

179. The **temperature** of a substance is a measure of the average **kinetic** energy of the molecules of the substance. Temperature can be measured directly using a thermometer.

Heat is the amount of thermal energy a substance contains, measured in joules. The amount of heat energy a substance contains depends upon a number of factors including its temperature and **mass**. Different substances also require different amounts of energy to produce a particular rise in temperature. This is called their **specific** heat capacity.

Specific heat capacity is defined as the energy required to raise the temperature of 1 kg of the substance by 1 °C. If heat energy is added to a substance its molecules gain kinetic energy and as a result the temperature of the substance rises.

180. $E_h = c\,m\,\Delta T$

181. (*a*) 167 200 J
(*b*) 902 J/kg°C
(*c*) 0·2 kg
(*d*) 5 °C
(*e*) 1908 J
(*f*) 20 °C

182. 9880 J

183. 100 320 J

184. (*a*) 1250 J/kg°C
(*b*) The block would loose heat energy to the surrounding air.

185. (*a*) 50 160 J
(*b*) 100·3 s
(*c*) Place an insulated lid on the container.

186. (*a*) 90 000 J
(*b*) 3000 J/kg°C
(*c*) There is no insulation around the container so it will loose a lot of heat to the surrounding air.

187. (*a*) 29·26 MJ
(*b*) (i) 6900 W
(ii) 4241 s (70 minutes)
(*c*) 81 %

188. (*a*) 76·6 °C
(*b*) It would be less effective as the new coolant cannot absorb as much energy for the same rise in temperature.

Reducing Energy waste

189. (*a*) A. Leaving lights on when no-one is there uses unnecessary energy.

B. If you heat more water than you need then the energy used to heat the excess water is wasted.

C. If the dishwasher is not full it will be used more often which uses energy unnecessarily.

D. Most heat escapes through the walls and roof

E. Even though standby is low power, lots of appliances can use up energy especially since they are on 24/7.

F. Doing things yourself keeps you fitter and doesn't use electricity eg. hand hedge clippers in the garden, hand whisk in the kitchen.

G. The same type of appliance can use quite different amounts of energy so look for A rated appliances.

H. Heat lost through windows can be reduced by double glazing.

I. The hot water tank will constantly lose heat as its hotter than its surroundings. If its will lagged this will slow losses down.

J. Showers use less hot water which you pay to heat so this saves energy.

K. Different energy suppliers have different rates. There can be better prices from competitors.

L. The hotter a room, the faster it will lose energy. Turning the room thermostat down means it loses heat less quickly.

(*b*) D. Insulating the walls and roof.

190. (*a*) The windows and doors.

(*b*) The older block is loosing more heat. The insulation put in when the house was built (if at all) will not be as great as the new building.

191. (*a*) The walls.

(*b*) Insulate the roof as this is where most energy is lost but it does not cost much money to do.