

7 Measurements

1 Measurement

Different units of measurement have been used in the past, some of them are still in use in UK and USA, but in most places is used the **Metric System of Measurements**.

The metric units are:

Length	metre (In U.S.A. "meter")
Area	square metre
Volume	cubic metre
Capacity	litre
Mass or weight	gram

It is very useful to be able to *estimate* lengths, masses, etc. because it may not always be easy to measure them. Some useful hints for estimating are listed below:

The height of a standard door is about 2 m.
The length of an adult pace is about 1 m.
The length of a size 8 (41 in Spain) shoe is about 30 cm.
Most adults are between 1.5 m and 1.8 m in height.
It takes about 15 minutes to walk one kilometre.
The mass of a standard bag of sugar is 1 kg.
The mass of a family car is about 1 tonne.
2 hectares = 20 000 m ² (about 3 football pitches).
A teaspoon holds about 5 ml of liquid.
The volume of a normal can of drink is about 330 cm ³ .

In England some imperial units are in common use today. People may for example give their height in feet and inches; give a distance in miles, their weight in stones or a capacity in gallons. We will see the relationships between the units of the **Imperial** and the **Metric** systems of measurement.

2 Metric Prefix Table

The metric (decimal) system uses a number of standard prefixes for units of length, mass, etc.

To change any of the other units of measurement into their **equivalent values in the main unit we have to** use the conversion factor given by the value of the prefix.

Remember:

Number	Prefix	Symbol	Number	Prefix	Symbol
10	deca	da	0.1	deci	d
100	hecto	h	0.01	centi	c
1000	kilo	k	0.001	mili	m
1,000,000	mega	M	0.000001	micro	μ
10 ⁹	giga	G	0.000000001	nano	n
10 ¹²	tera	T	0.000000000001	pico	p

3. Length

The main unit of length is the metre; it is very useful to be able to convert between different units. This is the conversion table:

	Kilometre	Hectometre	Decametre	Metre	Decimetre	Centimetre	Millimetre
Kilometre km	1	10	100	1000	10000	100000	1000000
Hectometre hm	0.1	1	10	100	1000	10000	100000
Decametre dam	0.01	0.1	1	10	100	1000	10000
Metre m	0.001	0.01	0.1	1	10	100	1000
Decimetre dm	0.0001	0.001	0.01	0.1	1	10	100
Centimetre cm	0.00001	0.0001	0.001	0.01	0.1	1	10
Millimetre mm	0.000001	0.00001	0.0001	0.001	0.01	0.1	1

Exercise 1 Measure the width of this page and write it in the seven different units of the table.

Exercise 2 Write all the following in centimetres.

- a) 4 cm 2 mm
- b) 18 cm 9 mm
- c) 75 mm
- d) 4 dm 3 cm 45 mm
- e) 7.8 m 43 dm
- f) 55.3 m
- g) 0.3 dam 5 cm 64 mm
- h) 0.05 hm 5 m 36 cm
- i) 4.6 km 0.3 dam 0.5 m 78 mm

Exercise 3 Write all the following in millimetres.

- a) 0.4 cm 12 mm
- b) 1.78 cm 15 mm
- c) 17.5 m

- d) 35 dm 13 cm 67 mm
- e) 17.4 m 45 dm
- f) 75.8 m
- g) 0.7 dam 5 m 64 mm
- h) 1.05 hm 15 m 36 cm
- i) 0.06 km 0.3 dam 1.6 m 38 dm

Exercise 4 Write all the following in metres.

- a) 10.4 cm 140 mm
- b) 198 cm 150 mm
- c) 17.5 km
- d) 37 hm 13 m 1067 mm
- e) 32.6 dam 470 dm
- f) 1275.8 mm
- g) 0.29 dam 5 m 765 mm
- h) 1.32 hm 150 m 3600 cm
- i) 0.005 km 0.12 dam 1.6 m 38 cm

Exercise 5 Write all the following in kilometres.

- a) 10700 cm 140000 mm
- b) 158 m 120000 mm
- c) 17.5 hm
- d) 346 hm 14m 10400 mm
- e) 320.9 dam 47000 dm
- f) 1275.8 dam
- g) 8.78 dam 500 m 775000 mm
- h) 43.32 hm 150000 m
- i) 0.005 km 14 dam 160 m 38000 cm

Exercise 6 Round each of the following measurements to the nearest centimetre.

- a) 3.84 cm
- b) 158 m 1.2 mm
- c) 415.5 mm
- d) 134 m 19 mm
- e) 342 dam 0.47 dm
- f) 1273.8 mm

Exercise 7 Round each of the following measurements to the nearest metre.

- a) 13.84 dm
- b) 333 m 12 dm
- c) 2473.5 mm
- d) 543 m 900 mm
- e) 78.9 dam 47.47 dm
- f) 7654.8 mm

4. Capacity

The main unit of capacity is the litre; this is the conversion table:

	Kilolitre	Hectolitre	Decalitre	Litre	Decilitre	Centilitre	Millilitre
Kilolitre kl	1	10	100	1000	10000	100000	1000000
Hectolitre hl	0.1	1	10	100	1000	10000	100000
Decalitre dal	0.01	0.1	1	10	100	1000	10000
Litre l	0.001	0.01	0.1	1	10	100	1000
Decilitre dl	0.0001	0.001	0.01	0.1	1	10	100
Centilitre cl	0.00001	0.0001	0.001	0.01	0.1	1	10
Millilitre ml	0.000001	0.00001	0.0001	0.001	0.01	0.1	1

Exercise 8 Write all the following in centilitres.

- a) 14 cl 32 ml
- b) 4 dl 3 cl 45 ml

c) 0.38 dal 5 cl 68 ml

Write all the following in litres.

a) 90.5 hl 5 l 36 cl

b) 15.6 kl 0.03 dal 3.6 l 668 ml

c) 4.2 kl 0.53 dal 0.5 l 780 ml

Write all the following in kilolitres.

a) 43107cl 670140000 ml

b) 73.39 hl 17000 l

Exercise 9 Round each of the following measurements to the nearest litre.

a) 16.84 dl

b) 543 l 640 ml

c) 127 l 98 dl

d) 2283.5 ml

5. Weight

The unit of weight is the gram, this is the conversion table:

	Kilogram	Hectogram	Decagram	Gram	Decigram	Centigram	Milligram
Kilogram kg	1	10	100	1000	10000	100000	1000000
Hectogram hg	0.1	1	10	100	1000	10000	100000
Decagram dag	0.01	0.1	1	10	100	1000	10000
Gram g	0.001	0.01	0.1	1	10	100	1000
Decigram dg	0.0001	0.001	0.01	0.1	1	10	100
Centigram cg	0.00001	0.0001	0.001	0.01	0.1	1	10
Milligram mg	0.000001	0.00001	0.0001	0.001	0.01	0.1	1

1 tonne = 1000 kg

Exercise 10 Find your own weight in all the units.

Exercise 11 (You must be groups of four). Calculate the average weight of the group.

Round the result to the nearest

a) kg

b) hg

c) dag

Exercise 12 The average weight of a group of ten boys is 72 kilograms 890 grams. When one boy leaves the group the average of the nine becomes 72.5 kg.

Find the weight of the boy who left the group.

Exercise 13 A bridge has been designed to support 550 tonnes. If the average weight of a vehicle is 1 tonne 850 kg, is it safe to have 300 vehicles on the bridge at one time?

6. Area

The S I unit of area is the **square metre**. To change any of these other units of area into their **equivalent values in square metres** use the operation given.

square	Kilometre	Hectometre	Decametre	Metre	Decimetre	Centimetre	Millimetre
Kilometre km²	X 1	X 10 ²	X 10 ⁴	X 10 ⁶	X 10 ⁸	X 10 ¹⁰	X 10 ¹²
Hectometre hm²	: 10 ²	1	X 10 ²	X 10 ⁴	X 10 ⁶	X 10 ⁸	X 10 ¹⁰
Decametre dam²	: 10 ⁴	: 10 ²	1	X 10 ²	X 10 ⁴	X 10 ⁶	X 10 ⁸
Metre m²	: 10 ⁶	: 10 ⁴	: 10 ²	1	X 10 ²	X 10 ⁴	X 10 ⁶
Decimetre dm²	: 10 ⁸	: 10 ⁶	: 10 ⁴	: 10 ²	1	X 10 ²	X 10 ⁴
Centimetre cm²	: 10 ¹⁰	: 10 ⁸	: 10 ⁶	: 10 ⁴	: 10 ²	1	X 10 ²
Millimetre mm²	: 10 ¹²	: 10 ¹⁰	: 10 ⁸	: 10 ⁶	: 10 ⁴	: 10 ²	1

Land measurements units: **Are = dam²**, **Hectare = hm²**

Exercise 14 Write all the following in m².

a) $3 \text{ km}^2 \ 5 \text{ hm}^2 \ 54 \text{ dm}^2$

b) $7,890 \text{ ha} \ 23 \text{ a}$

c) $30,000 \text{ dm}^2$

Write all the following in ares and in hectares.

d) $90.5 \text{ km}^2 \ 5 \text{ hm}^2 \ 36 \text{ dam}^2$

e) $1.6 \text{ dam}^2 \ 0.03 \text{ km}^2 \ 34500 \text{ dm}^2$

f) $5,000,000 \text{ cm}^2$

7. Volume

The distinction between 'Volume' and 'Capacity' is artificial and kept here only for historic reasons. A **cubic metre** is **1000 litres**, a **cubic decimetre** is a **litre**, and a **cubic centimetre** is a **millilitre**. This is the conversion table:

cubic	Kilometre	Hectometre	Decametre	Metre	Decimetre	Centimetre	Millimetre
Kilometre km³	X 1	X 10 ³	X 10 ⁶	X 10 ⁹	X 10 ¹²	X 10 ¹⁵	X 10 ¹⁸
Hectometre hm³	: 10 ³	1	X 10 ³	X 10 ⁶	X 10 ⁹	X 10 ¹²	X 10 ¹⁵
Decametre dam³	: 10 ⁶	: 10 ³	1	X 10 ³	X 10 ⁶	X 10 ⁹	X 10 ¹²
Metre m³	: 10 ⁹	: 10 ⁶	: 10 ³	1	X 10 ³	X 10 ⁶	X 10 ⁹
Decimetre dm³	: 10 ¹²	: 10 ⁹	: 10 ⁶	: 10 ³	1	X 10 ³	X 10 ⁶
Centimetre cm³	: 10 ¹⁵	: 10 ¹²	: 10 ⁹	: 10 ⁶	: 10 ³	1	X 10 ³
Millimetre mm³	: 10 ¹⁸	: 10 ¹⁵	: 10 ¹²	: 10 ⁹	: 10 ⁶	: 10 ³	1

Exercise 15 Write all the following in m³.

a) 0.0003 km^3 0.05 hm^3 5400 dm^3

b) $7,320 \text{ dm}^3$ 5000 cm^3

c) $210,000 \text{ dm}^3$

Write all the following in cm^3 and dm^3

d) 0.0123 m^3 40 dm^3 45800 mm^3

e) 0.0000045 dam^3 0.323 m^3 0.234 dm^3

f) $5,000,000 \text{ mm}^3$

Exercise 16 Write all the following in litres and in centilitres.

a) 0.0000125 hm^3 5.4 dm^3

b) 0.000043 hm^3 50000 cm^3

c) $210,000$ millilitres

Write all the following in cm^3 and dm^3

d) 10.7 kl 40 hl $44,300 \text{ l}$

e) 6.7 kl 234 cl

f) $5,000,000 \text{ ml}$

8. Imperial Units of Length, Capacity and Mass

The imperial system was used, until very recently, for all weights and measures throughout the UK. There are many aspects of everyday life where the system is still in common usage. Miles instead of kilometres are used.

The units of length are:

1 mile = 1609.344 metres
1 yard = 0.9144 metres
1 foot = 0.3048 metres
1 inch = 0.0254 metres

The relationships are:

from \ to	miles	yards	feet	inches
mile	1	1760	5280	63360
yard	(1/1760)	1	3	36
foot	(1/5280)	(1/3)	1	12
inch	(1/63360)	(1/36)	(1/12)	1

The following list gives some help to you.

- The height of a tall adult is about 6 feet.
- The width of an adult thumb is about 1 inch.
- The length of a size 41, 8 in England, shoe is about 1 foot.
- An adult pace is about 1 yard.

You will find the following abbreviations used for imperial units:

1 yard = 1 yd	6 feet = 6ft = 6'
9 inches = 9 in = 9 "	8 ounces = 8 oz
7 pounds = 7 lb	

Do not to use m as an abbreviation for miles because m is a standard abbreviation for metres.

For areas, apart from the correspondent to the length units, it is also used the **acre**.

1 acre	43560 feet²	6272640 inches²	4046.8... meters²	(1/640) miles²	4840 yards²
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In U.S.A. the conversion table (not all exact) for units of volume and capacity are:

from \ to	feet³	gallons	inches³	litres	pints	quarts	yards³
foot³		7.48	1728	28.3	59.8	29.9	(1/27)
gallon	0.13		231	3.78	8	4	0.0049
inch³	(1/1728)	(1/231)		0.016	(1/29)	(1/57.75)	(1/47)
pint	0.0167	(1/8)	28.87	0.47		(1/2)	0.0006
quart	0.033	(1/4)	57.75	1.057	2		0.00123
yard³	27	0.0049	46656	764	1615.79	807.896	

Remember that all these relationships are not exact.

But a gallon in U.K. are **4.546** litres, so for units of volume and capacity we have:

Common for U.S.A. and U.K.

1 gallon = 4 quarts = 8 pints

Only for USA

**1 gallon = 3.78 litres
1 pint = 0.47 litres**

Only for UK

**1 gallon = 4.546 litres
1 pint = 0.57 litres**

Some of the units of mass are:

1 ton (UK) = 1016 kg

1 ton (USA) = 907 kg

1 stone = 6.35 kg

1 pound = 0.453 kg

(Be careful 1 tonne is 1000 kg)

The following list gives some help to you.

- The mass of a bag of sugar is just over 2 pounds.
- The weight of an adult is between 10 and 16 stones
- Chocolate is sold in Spain in pounds and ounces.

The conversion table (not all exact) for units of weight is:

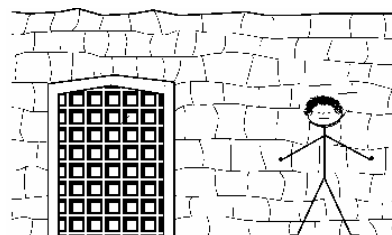
from \ to	stone	pound	ounce	kg
stone	1	14	224	6.35
pound	1/14	1	16	0.45
Ounce	1/224	1/14	1	0.028
Kg	0.16	2.2	35.3	1

Exercise 17

a) Estimate the length of the following line, in inches:



b) The picture shows a man standing with a gate in it:
Estimate the height in feet of both the gate and the wall.



c) Estimate the size of the top of your desk, in inches.

d) Estimate the heights of 4 of your friends, in feet and inches.

e) Estimate the length and width of your classroom, in feet.

f) Estimate the total mass of 3 text books, in pounds.

g) Estimate the mass of an apple, in ounces. (Remember that there are 16 ounces in 1 lb.)

h) Estimate the capacity of a mug, in pints.

i) Estimate your own weight in stones and pounds.

Exercise 18 While on holiday in France, a family sees the following road-sign:

PARIS 342 km

How many *miles* is the family from Paris?

Exercise 19 While on holiday in England you see the following road-sign:

How many km/h is the speed limit?



Exercise 20 A bottle contains 2.5 litres of milk. How many *pints* of milk does the bottle contain?

Exercise 21 Vera buys 27 litres of petrol for her car. How many *gallons* of petrol does she buy? if she buys 4 gallons of petrol. How many litres does she buy?

Exercise 22 Change the following lengths into appropriate units of the metric system (cm, m or km).

4 feet

8 feet 7 inches

5 yards 2 feet

7 feet

5.5 feet

1 mile

4 feet 2 inches

2 yards

17 inches

95 inches

Change the following lengths into metres:

60 inches

29 inches

48 inches

240 inches

Exercise 23 Change the following masses into kg:

- a) 7 pounds
- b) 11 pounds
- c) 36 pounds
- d) 904 pounds
- e) 2 stones
- f) 9 stones 12 pounds
- g) 5.5 pounds

Change the following masses into pounds or pounds and ounces:

- a) 3.5kg
- b) 500 g
- c) 720 ounces
- d) 750 g
- e) 40 ounces
- f) 125 g

Exercise 24 Change the following volumes into litres:

- a) 5 gallons
- b) 11 gallons
- c) 63 gallons

d) 412 gallons

Exercise 25 Change the following volumes into gallons and litres:

a) 56 pints

b) 528 pints

c) 2 pints

d) 160 pints

e) 12 pints

Into gallons

f) 25 l

g) 120 l

h) 5.5 l

Exercise 26 A recipe requires 2 lb of flour. Give the equivalent amount of flour in:

a) Grams

b) Kilograms

c) Ounces

Exercise 27 The capacity of a fuel tank is 30 gallons. What is the capacity of the tank in:

a) Litres

b) Pints

Exercise 28 A cow produces an average of 18 pints of milk each time she is milked. Convert this to litres, giving your answer to 1 decimal place.

9. Temperature

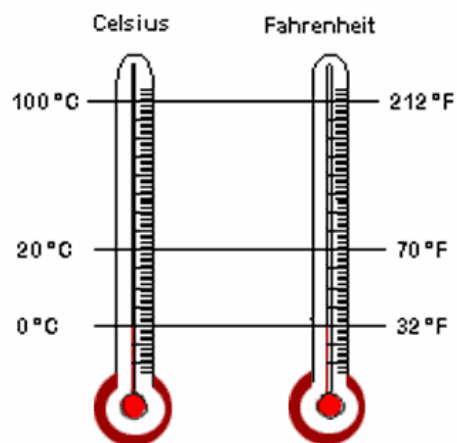
There are two main temperature scales, each one being named after the person who invented it.

G D FAHRENHEIT (1686-1736) a German physicist, in about 1714 proposed the first practical scale.

He called the freezing-point of water **32 degrees** (so as to avoid negative temperatures) and the boiling-point **212 degrees**.

Anders CELSIUS (1701-1744) a Swedish astronomer, proposed the 100-degree scale (from 0 to 100) in 1742.

This was widely adopted as the centigrade scale. But since grades and centigrade were also measures of angle, in 1947 it officially became the Celsius scale.



Nowadays, the CELSIUS scale is the preferred scale in our everyday lives.

However, the Fahrenheit scale is still widely used in U.S.A. and there frequently is a need to be able to change from one to the other.

To change temperature given in Fahrenheit (*F*) to Celsius (*C*)

1. Start with (*F*)
2. Subtract 32
3. Multiply by 5 and divide by 9
4. The answer is (*C*)

To change temperature given in Celsius (*C*) to Fahrenheit (*F*)

1. Start with (*C*)
2. Multiply by 9 and divide by 5
3. Add on 32
4. The answer is (*F*)

Example 1: **To convert 45° F to °C**

1. 45° F
2. $45 - 32 = 13$
3. $(13 \times 5) / 9 = 7.2$
4. 7.2° C

Example 2: **To convert 25° C to °F**

1. 25° C
2. $25 \times 9 : 5 = 45$

3. $45+32 =77$
 4. 77°F

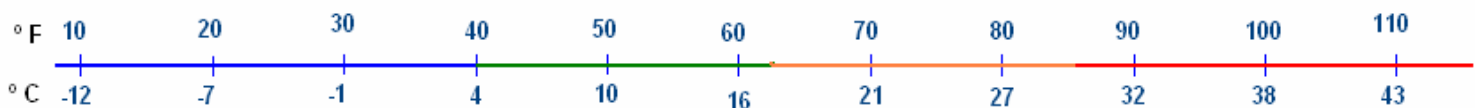
Exercise 29 Change the following temperatures into $^{\circ}\text{C}$ scale:

- a) 72°F
 b) 100°F
 c) 93°F
 d) 5°F
 e) -52°F
 f) Write the temperature of the human body in $^{\circ}\text{F}$
 g) Write a list of 6 temperatures in $^{\circ}\text{C}$ and $^{\circ}\text{F}$ including the ones that you consider more interesting.

Exercise 30 Change the following temperatures into $^{\circ}\text{F}$ scale:

- a) 37°C
 b) 100°C
 c) 18°C
 d) -5°C
 e) -22°C

Compare your answers in this scale that is only an approximation.



Solutions

Exercise 1 21 cm, 210 mm, 2.1 dm, 0.21 m, 0.021 dam, 0.0021 hm, 0.00021km.

Exercise 2 a) 4.2 cm, b) 18.9 cm, c) 7.5 cm, d) 47.5 cm e) 1210 cm, f) 5530 cm, g) 311.4 cm, h) 1036 cm, i) 460357.8 cm.

Exercise 3 a) 16 mm, b) 32.8 mm, c) 17,500 mm, d) 3697 mm, e) 21,900 mm, f) 75,800 mm, g) 12,064 mm, h) 120,360 mm, i) 64,980 mm.

Exercise 4 a) 0.244 m, b) 2.13 m, c) 17,500 m, d) 3714.067 m, e) 373 m, f) 1.2758 m, g) 8.665 m, h) 318 m, i) 8.18 m.

Exercise 5 a) 0.247 km, b) 0.278 km, c) 1.75 km, d) 34.6244 km, e) 7.909 km, f) 12.758 km, g) 1.3628 km, h) 154.332 km, i) 0.685 km.

Exercise 6 a) 4 cm, b) 15800 cm, c) 42 cm, d) 13402 cm, e) 342005 cm, f) 127 cm.

Exercise 7 a) 1 m, b) 334 m, c) 2 m, d) 544 m, e) 794 m, f) 8 m.

Exercise 8 a) 17.2 cl, b) 47.5 cl, c) 386.8 cl. a) 9055.36 l, b) 15604.568 l, c) 426.58 l. a) 670.57107 kl, b) 24.339 kl.

Exercise 9 a) 2 l, b) 544 l, c) 137 l, d) 2 l.

Exercise 10 Different for each case.

Exercise 11 Different for each case.

Exercise 12 76.4 kg.

Exercise 13 No, the total weight is 555 tonnes.

Exercise 14 a) 3,055,400 m², b) 78,902,300 m², c) 300 m², d) 905,536 a, 9055.36 ha; e) 305.05 a, 3.0505 ha; f) 5 a, 0.05 ha.

Exercise 15 a) 30505.4 m³, b) 7.325 m³, c) 210 m³. d) 52.3458 dm³, 52345.8 cm³, e) 327.734 dm³, 327734 cm³, f) 5 dm³ 5000 cm³.

Exercise 16 a) 12,505.4 l, 1,250,540 cl, b) 43,050 l, 4,305,000 cl, c) 210 l, 21,000 cl, d) 59,000,000 cm³, 59,000 dm³, e) 6,702,340 cm³, 6,702.34 dm³, f) 5,000,000 cm³, 5,000 dm³.

Exercise 17 a) 4 inches, b), c), d), e) and f) different solutions, g) 8 ounces, h) half a pint, i) different solutions.

Exercise 18 201.3 miles.

Exercise 19 64.4 km/h.

Exercise 20 4.39 pints.

Exercise 21 5.94 gallons, 18.18 litres.

Exercise 22 4 feet = 1.22 m, 8 feet 7 inches = 2.62 m, 5 yards 2 feet = 5.49 m, 7 feet = 2.13 m, 5.5 feet = 1.68 m, 1 mile = 1.609 km, 4 feet 2 inches = 15.24 m, 2 yards = 1.83 m, 17 inches = 43.2 cm, 95 inches = 2.41 m, 60" = 1.524 m, 29" = 0.737 m, 48" = 1.219 m, 240" = 6.1 m.

Exercise 23 a) 3.15 kg, b) 4.95 kg, c) 16.2 kg, d) 406.8 kg, e) 12.7 kg, f) 62.55 kg, g) 2.475 kg. a) 7 lb 3.5 ounces, b) 1lb 1.6 ounces, c) 45 lb, d) 1 lb 10.4 ounces, e) 2 lb 8 ounces, f) 4.4 ounces.

Exercise 24 a) 22.73 l, b) 50 l, c) 286.4 l, d) 1872.95 l.

Exercise 25 a) 7 gallons, 31.8 l, b) 66 gallons, 300 l, c) .25 gallons, 1.14 l, d) 20 gallons, 90.92 l, e) 1.5 gallons, 6.8 l, Into gallons, f) 5.5 gallons, g) 26.4 gallons, h) 1.21 gallons.

Exercise 26 a) 900 grams, b) 0.9 kilograms, c) 32 ounces.

Exercise 27 a) 136.38 l, b) 240 pints.

Exercise 28 10.3 l

Exercise 29 a) 22.2° C, b) 37.8° C, c) 33.9° C, d) – 15° C, e) – 46.7° C, f) 97.7° F.

Exercise 30 a) 98.6° F, b) 212° F, c) 64.4° F, d) 23° F, e) -7.6° F.