



PHYSICS

STAGE 2

FORMULAE AND DATA

2013

Copyright

© School Curriculum and Standards Authority, 2012

This document – apart from any third party copyright material contained in it – may be freely copied, or communicated on an intranet, for non-commercial purposes in educational institutions, provided that it is not changed and that the School Curriculum and Standards Authority is acknowledged as the copyright owner.

Copying or communication for any other purpose can be done only within the terms of the Copyright Act or with prior written permission of the Authority. Copying or communication of any third party copyright material can be done only within the terms of the Copyright Act or with permission of the copyright owners.

This document is valid for teaching and examining until 31 December 2013.

Forces and motion

Mean velocity	$v_{av} = \frac{s}{t} = \frac{v + u}{2}$
Equations of motion	$a = \frac{v - u}{t}$; $s = ut + \frac{1}{2} at^2$; $v^2 = u^2 + 2as$; $v = u + at$
Force	$F = ma$
Weight force	$F = mg$
Momentum	$p = mv$; $\Sigma p_{\text{before}} = \Sigma p_{\text{after}}$
Change in momentum (impulse)	$Ft = mv - mu$
Kinetic energy	$E_k = \frac{1}{2} mv^2$
Gravitational potential energy	$E_p = mgh$
Work done	$W = Fs = \Delta E$
Power	$P = \frac{W}{t} = \frac{\Delta E}{t} = Fv_{av}$

Note: the variable t refers to the 'time taken' sometimes referred to as the 'change in time' or Δt .

Nuclear physics

Activity	$A = \frac{\Delta N}{t}$
Half-life	$A = A_0 \left(\frac{1}{2}\right)^n$
Absorbed radiation dose	absorbed dose = $\frac{E}{m}$
Dose equivalent	dose equivalent = absorbed dose \times quality factor
Mass-energy relationship	$E = mc^2$

Heating and cooling

Change of temperature	$Q = mc\Delta T$
Change of state	$Q = mL$
Absolute zero	0 K = -273°C

Electricity and magnetism

Electric current	$I = \frac{q}{t}$
Work and energy	$W = Vq = VIt$
Ohm's law	$V = IR$
Resistances in series	$R_T = R_1 + R_2 + \dots$
Resistances in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
Power	$P = VI = I^2R = \frac{V^2}{R}$

Physical constants

Speed of light in vacuum or air	c	=	$3.00 \times 10^8 \text{ m s}^{-1}$
Electron charge	e	=	$-1.60 \times 10^{-19} \text{ C}$
Electron volt.....	1 eV	=	$1.60 \times 10^{-19} \text{ J}$
Unified atomic mass unit	1 u	=	$1.66 \times 10^{-27} \text{ kg}$
Rest mass of electron.....	m_e	=	$9.11 \times 10^{-31} \text{ kg}$
Rest mass of proton	m_p	=	$1.67 \times 10^{-27} \text{ kg}$
Rest mass of neutron	m_n	=	$1.67 \times 10^{-27} \text{ kg}$
Rest mass of alpha.....	m_α	=	$6.64 \times 10^{-27} \text{ kg}$
Mass–energy equivalent.....	1 u	=	931 MeV
Tonne.....	1 t	=	$10^3 \text{ kg} = 10^6 \text{ g}$

Physical data

Mean acceleration due to gravity on Earth.....	g	=	9.80 m s^{-2}
Specific heat capacity of water	c_w	=	$4.18 \times 10^3 \text{ J K}^{-1} \text{ kg}^{-1}$
Specific heat capacity of ice	c_i	=	$2.10 \times 10^3 \text{ J K}^{-1} \text{ kg}^{-1}$
Specific heat capacity of steam.....	c_s	=	$2.00 \times 10^3 \text{ J K}^{-1} \text{ kg}^{-1}$
Latent heat of fusion for H_2O	L_f	=	$3.34 \times 10^5 \text{ J kg}^{-1}$
Latent heat of vaporisation for H_2O	L_v	=	$2.26 \times 10^6 \text{ J kg}^{-1}$

Quality factors

Approximate quality factor for alpha radiation	QF_α	=	20
Approximate quality factor for beta radiation	QF_β	=	1
Approximate quality factor for gamma radiation...	QF_γ	=	1
Approximate quality factor for slow neutrons.....	QF_{sn}	=	3
Approximate quality factor for fast neutrons	QF_{fn}	=	10

Prefixes of the metric system

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{-3}	milli	m
10^9	giga	G	10^{-6}	micro	μ
10^6	mega	M	10^{-9}	nano	n
10^3	kilo	k	10^{-12}	pico	p

Periodic table

1

H

hydrogen

1.008

3

Li

lithium

6.941

11

Na

sodium

22.99

19

K

potassium

39.10

37

Rb

rubidium

85.47

55

Cs

caesium

132.9

87

Fr

francium

4

Be

beryllium

9.012

12

Mg

magnesium

24.31

20

Ca

calcium

40.08

38

Sr

strontium

87.62

56

Ba

barium

137.3

88

Ra

radium

226.0

21

Sc

scandium

44.96

39

Y

yttrium

88.91

57–71

*La

lanthanum

138.9

89–103

**Ac

actinium

22

Ti

titanium

47.88

40

Zr

zirconium

91.22

72

Hf

hafnium

178.5

104

Rf

rutherfordium

23

V

vanadium

50.94

41

Nb

niobium

92.91

73

Ta

tantalum

180.9

105

Db

dubnium

24

Cr

chromium

52.00

42

Mo

molybdenum

95.94

74

W

tungsten

183.9

106

Sg

seaborgium

25

Mn

manganese

54.94

43

Tc

technetium

75

Re

rhenium

186.2

107

Bh

bohrium

26

Fe

iron

55.85

44

Ru

ruthenium

101.1

76

Os

osmium

190.2

108

Hs

hassium

27

Co

cobalt

58.93

45

Rh

rhodium

102.9

77

Ir

iridium

192.2

109

Mt

meitnerium

28

Ni

nickel

58.69

46

Pd

palladium

106.4

78

Pt

platinum

195.1

110

Ds

darmstadtium

29

Cu

copper

63.55

47

Ag

silver

107.9

79

Au

gold

197.0

111

Rg

roentgenium

30

Zn

zinc

65.38

48

Cd

cadmium

112.4

80

Hg

mercury

200.6

112

Cn

copernicium

5

B

boron

10.81

13

Al

aluminium

26.98

6

C

carbon

12.01

14

Si

silicon

28.09

7

N

nitrogen

14.01

15

P

phosphorus

30.97

8

O

oxygen

16.00

16

S

sulfur

32.06

9

F

fluorine

19.00

17

Cl

chlorine

35.45

10

Ne

neon

20.18

18

Ar

argon

39.95

19

K

potassium

39.10

37

Rb

rubidium

85.47

55

Cs

caesium

132.9

87

Fr

francium

20

Ca

calcium

40.08

38

Sr

strontium

87.62

56

Ba

barium

137.3

88

Ra

radium

226.0

21

Sc

scandium

44.96

39

Y

yttrium

88.91

57–71

*La

lanthanum

138.9

89–103

**Ac

actinium

22

Ti

titanium

47.88

40

Zr

zirconium

91.22

72

Hf

hafnium

178.5

104

Rf

rutherfordium

23

V

vanadium

50.94

41

Nb

niobium

92.91

73

Ta

tantalum

180.9

105

Db

dubnium

24

Cr

chromium

52.00

42

Mo

molybdenum

95.94

74

W

tungsten

183.9

106

Sg

seaborgium

25

Mn

manganese

54.94

43

Tc

technetium

75

Re

rhenium

186.2

107

Bh

bohrium

26

Fe

iron

55.85

44

Ru

ruthenium

101.1

76

Os

osmium

190.2

108

Hs

hassium

27

Co

cobalt

58.93

45

Rh

rhodium

102.9

77

Ir

iridium

192.2

109

Mt

meitnerium

28

Ni

nickel

58.69

46

Pd

palladium

106.4

78

Pt

platinum

195.1

110

Ds

darmstadtium

29

Cu

copper

63.55

47

Ag

silver

107.9

79

Au

gold

197.0

111

Rg

roentgenium

30

Zn

zinc

65.38

48

Cd

cadmium

112.4

80

Hg

mercury

200.6

112

Cn

copernicium

31

Ga

gallium

69.72

49

In

indium

114.8

81

Tl

thallium

204.4

113

Nh

nihonium

32

Ge

germanium

72.59

50

Sn

tin

118.7

82

Pb

lead

207.2

114

Fl

flerovium

33

As

arsenic

74.92

51

Sb

antimony

121.8

83

Bi

bismuth

209.0

115

Mc

moscovium

34

Se

selenium

78.96

52

Te

tellurium

127.6

84

Po

polonium

116

Lv

livermorium

35

Br

bromine

79.90

53

I

iodine

126.9

85

At

astatine

117

Ts

tennessine

36

Kr

krypton

83.80

54

Xe

xenon

131.3

86

Rn

radon

118

Og

oganeson

2

He

helium

4.003

10

Ne

neon

20.18

18

Ar

argon

39.95

36

Kr

krypton

83.80

54

Xe

xenon

131.3

86

Rn

radon

68

Er

erbium

167.3

100

Fm

fermium

70

Yb

ytterbium

173.0

102

No

nobelium

71

Lu

lutetium

175.0

103

Lr

lawrencium

66

Dy

dysprosium

162.5

98

Cf

californium

67

Ho

holmium

164.9

99

Es

einsteinium

69

Tm

thulium

168.9

101

Md

mendelevium

72

Hf

hafnium

178.5

104

Rf

rutherfordium

73

Ta

tantalum

180.9

105

Db

dubnium

74

W

tungsten

183.9

106

Sg

seaborgium

75

Re

rhenium

186.2

107

Bh

bohrium

76

Os

osmium

190.2

108

Hs

hassium

77

Ir

iridium

192.2

109

Mt

meitnerium

78

Pt

platinum

195.1

110

Ds

darmstadtium

79

Au

gold

197.0

111

Rg

roentgenium

80

Hg

mercury

200.6

112

Cn

copernicium

81

Tl

thallium

204.4

113

Nh

nihonium

82

Pb

lead

207.2

114

Fl

flerovium

83

Bi

bismuth

209.0

115

Mc

moscovium

84

Po

polonium

116

Lv

livermorium

85

At

astatine

117

Ts

tennessine

86

Rn

radon

118

Og

oganeson

64

Gd

gadolinium

157.3

96

Cm

curium

65

Tb

terbium

158.9

97

Bk

berkelium

66

Dy

dysprosium

162.5

98

Cf

californium

67

Ho

holmium

164.9

99

Es

einsteinium

68

Er

erbium

167.3

100

Fm

fermium

69

Tm

thulium

168.9

101

Md

mendelevium

70

Yb

ytterbium

173.0

102

No

nobelium

71

Lu

lutetium

175.0

103

Lr

lawrencium

62

Sm

samarium

150.4

94

Pu

plutonium

63

Eu

europium

152.0

95

Am

americium

64

Gd

gadolinium

157.3

96

Cm

curium

65

Tb

terbium

158.9

97

Bk

berkelium

66

Dy

dysprosium

162.5

98

Cf

californium

67

Ho

holmium

164.9

99

Es

einsteinium

68

Er

erbium

167.3

100

Fm

fermium

69

Tm

thulium

168.9

101

Md

mendelevium

70

Yb

ytterbium

173.0

102

No

nobelium

71

Lu

lutetium

175.0

103

Lr

lawrencium

59

Pr

praseodymium

140.9

91

Pa

protactinium

60

Nd

neodymium

144.2

92

U

uranium

238.0

61

Pm

promethium

93

Np

neptunium

62

Sm

samarium

150.4

94

Pu

plutonium

63

Eu

europium

152.0

95

Am

americium

64

Gd

gadolinium

157.3

96

Cm

curium

65

Tb

terbium

158.9

97

Bk

berkelium

66

Dy

dysprosium

162.5

98

Cf

californium

67

Ho

holmium

164.9

99

Es

einsteinium

68

Er

erbium

167.3

100

Fm

fermium

69

Tm

thulium

168.9

101

Md

mendelevium

70

Yb

ytterbium

173.0

102

No

nobelium

71

Lu

lutetium

175.0

103

Lr

lawrencium

58

Ce

cerium

140.1

90

Th

thorium

232.0

59

Pr

praseodymium

140.9

91

Pa

protactinium

60

Nd

neodymium

144.2

92

U

uranium

238.0

61

Pm

promethium

93

Np

neptunium

62

Sm

samarium

150.4

94

Pu

plutonium

63

Eu

europium

152.0

95

Am

americium

64

Gd

gadolinium

157.3

96

Cm

curium

65

Tb

terbium

158.9

97

Bk

berkelium

66

Dy

dysprosium

162.5

98

Cf

californium

67

Ho

holmium

164.9

99

Es

einsteinium

68

Er

erbium

167.3

100

Fm

fermium

69

Tm

thulium

168.9

101

Md

mendelevium

70

Yb

ytterbium

173.0

102

No

nobelium

71

Lu

lutetium

175.0

103

Lr

lawrencium

57

*La

lanthanum

138.9

89

**Ac

actinium

58

Ce

cerium

140.1

90

Th

thorium

232.0

59

Pr

praseodymium

140.9

91

Pa

protactinium

60

Nd

neodymium

144.2

92

U

uranium

238.0

61

Pm

promethium

93

Np

neptunium

62

Sm

samarium

150.4

94

Pu

plutonium

63

Eu

europium

152.0

95

Am

americium

64

Gd

gadolinium

157.3

96

Cm

curium

65

Tb

terbium

158.9

97

Bk

berkelium

66

Dy

dysprosium

162.5

98

Cf

californium

67

Ho

holmium

164.9

99

Es

einsteinium

68

Er

erbium

167.3

100

Fm

fermium

69

Tm

thulium

168.9

101

Md

mendelevium

70

Yb

ytterbium

173.0

102

No

nobelium

71

Lu

lutetium

175.0

103

Lr

lawrencium

56

*La

lanthanum

138.9

88

**Ac

actinium

57

Ce

cerium

140.1

89

Th

thorium

232.0

58

Pr

praseodymium

140.9

90

Pa

protactinium

59

Nd

neodymium

144.2

91

U

uranium

238.0

60

Pm

promethium

92

Np

neptunium

61

Sm

samarium

150.4

93

Pu

plutonium

62

Eu

europium

152.0

94

Am

americium

63

Gd

gadolinium

157.3

95

Cm

curium

64

Tb

terbium

158.9

96

Bk

berkelium

65

Dy

dysprosium

162.5

97

Cf

californium

66

Ho

holmium

164.9

98

Es

einsteinium

67

Er

erbium

167.3

99

Fm

fermium

68

Tm

thulium

168.9

100

Md

mendelevium

69

Yb

ytterbium

173.0

101

No

nobelium

70

Lu

lutetium

175.0

102

Lr

lawrencium

55

*La

lanthanum

138.9

87

**Ac

actinium

56

Ce

cerium

140.1

88

Th

thorium

232.0

57

Pr

praseodymium

140.9

89

Pa

protactinium

58

Nd

neodymium

144.2

90

U

uranium

238.0

59

Pm

promethium

91

Np

neptunium

60

Sm

samarium

150.4

92

Pu

plutonium

61

Eu

europium

152.0

93

Am

americium

62

Gd

gadolinium

157.3

94

Cm

curium

63

Tb

terbium

158.9

95

Bk

berkelium

64

Dy

dysprosium

162.5

96

Cf

californium

65

Ho

holmium

164.9

97

Es

einsteinium

66

Er

erbium

167.3

98

Fm

fermium

67

Tm

thulium

168.9

99

Md

mendelevium

68

Yb

ytterbium

173.0

100

No

nobelium

69

Lu

lutetium

1