



## GCE A LEVEL

1420U40-1A



S19-1420U40-1A

## PHYSICS – A2 unit 4

MONDAY, 17 JUNE 2019 – MORNING

## Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each A2 unit 4 Physics examination.

Centres are asked to issue this booklet to candidates at the start of the course to enable them to become familiar with its contents and layout.

### Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ ms}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ Js}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ JK}^{-1}$
Speed of light in vacuo	$c = 3.00 \times 10^8 \text{ ms}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ mK}$
Hubble constant	$H_0 = 2.20 \times 10^{-18} \text{ s}^{-1}$

$$T/\text{K} = \theta/^\circ\text{C} + 273.15$$

$$1 \text{ parsec} = 3.09 \times 10^{16} \text{ m}$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

$$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$$

$$\frac{1}{4\pi\epsilon_0} \approx 9.0 \times 10^9 \text{ F}^{-1} \text{ m}$$

## AS

$\rho = \frac{m}{V}$	$I = \frac{\Delta Q}{\Delta t}$																							
$v = u + at$	$I = nAve$																							
$x = \frac{1}{2}(u + v)t$	$R = \frac{V}{I}$																							
$x = ut + \frac{1}{2}at^2$	$P = IV = I^2R = \frac{V^2}{R}$																							
$v^2 = u^2 + 2ax$	$R = \frac{\rho l}{A}$																							
$\Sigma F = ma$	$V = E - Ir$																							
$p = mv$	$\frac{V}{V_{\text{total}}} \left[ \text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right] = \frac{R}{R_{\text{total}}}$																							
$W = Fx \cos \theta$	$T = \frac{1}{f}$																							
$\Delta E = mg\Delta h$	$c = f\lambda$																							
$E = \frac{1}{2}kx^2$	$\lambda = \frac{a\Delta y}{D}$																							
$E = \frac{1}{2}mv^2$	$d \sin \theta = n\lambda$																							
$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$	$n = \frac{c}{v}$																							
$P = \frac{W}{t} = \frac{\Delta E}{t}$	$n_1v_1 = n_2v_2$																							
efficiency = $\frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$	$n_1 \sin \theta_1 = n_2 \sin \theta_2$																							
$F = kx$	$n_1 \sin \theta_C = n_2$																							
$\sigma = \frac{F}{A}$	$E_{k \text{ max}} = hf - \phi$																							
$\varepsilon = \frac{\Delta l}{l}$	$p = \frac{h}{\lambda}$																							
$E = \frac{\sigma}{\varepsilon}$																								
$W = \frac{1}{2}Fx$																								
$\lambda_{\text{max}} = \frac{W}{T}$																								
$P = A\sigma T^4$																								
<table border="1"> <thead> <tr> <th></th> <th colspan="2">leptons</th> <th colspan="2">quarks</th> </tr> <tr> <th>particle (symbol)</th> <th>electron (<math>e^-</math>)</th> <th>electron neutrino (<math>\nu_e</math>)</th> <th>up (u)</th> <th>down (d)</th> </tr> </thead> <tbody> <tr> <th>charge (e)</th> <td>-1</td> <td>0</td> <td><math>+\frac{2}{3}</math></td> <td><math>-\frac{1}{3}</math></td> </tr> <tr> <th>lepton number</th> <td>1</td> <td>1</td> <td>0</td> <td>0</td> </tr> </tbody> </table>						leptons		quarks		particle (symbol)	electron ( $e^-$ )	electron neutrino ( $\nu_e$ )	up (u)	down (d)	charge (e)	-1	0	$+\frac{2}{3}$	$-\frac{1}{3}$	lepton number	1	1	0	0
	leptons		quarks																					
particle (symbol)	electron ( $e^-$ )	electron neutrino ( $\nu_e$ )	up (u)	down (d)																				
charge (e)	-1	0	$+\frac{2}{3}$	$-\frac{1}{3}$																				
lepton number	1	1	0	0																				

## A2

$\omega = \frac{\theta}{t}$	$C = \frac{\epsilon_0 A}{d}$
$v = \omega r$	$E = \frac{V}{d}$
$a = \omega^2 r$	$U = \frac{1}{2} QV$
$a = \frac{v^2}{r}$	$Q = Q_0 \left( 1 - e^{-\frac{t}{RC}} \right)$
$F = \frac{mv^2}{r}$	$Q = Q_0 e^{-\frac{t}{RC}}$
$F = m\omega^2 r$	$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$
$a = -\omega^2 x$	$F = G \frac{M_1 M_2}{r^2}$
$x = A \cos(\omega t + \epsilon)$	$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$
$T = \frac{2\pi}{\omega}$	$g = \frac{GM}{r^2}$
$v = -A\omega \sin(\omega t + \epsilon)$	$V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$
$T = 2\pi \sqrt{\frac{m}{k}}$	$PE = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r}$
$T = 2\pi \sqrt{\frac{l}{g}}$	$V_g = -\frac{GM}{r}$
$pV = nRT$ and $pV = NkT$	$PE = -\frac{GM_1 M_2}{r}$
$p = \frac{1}{3} \rho c^2 = \frac{1}{3} \frac{N}{V} mc^2$	$W = q\Delta V_E$
$M / \text{kg} = \frac{M_r}{1000}$	$W = m\Delta V_g$
$n = \frac{\text{total mass}}{\text{molar mass}}$	$\frac{\Delta \lambda}{\lambda} = \frac{v}{c}$
$k = \frac{R}{N_A}$	$v = H_0 D$
$U = \frac{3}{2} nRT = \frac{3}{2} NkT$	$\rho_c = \frac{3H_0^2}{8\pi G}$
$W = p\Delta V$	$r_1 = \frac{M_2}{M_1 + M_2} d$
$\Delta U = Q - W$	$T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$
$Q = mc\Delta\theta$	$A = \lambda N$
$C = \frac{Q}{V}$	$N = N_0 e^{-\lambda t}$

$A = A_0 e^{-\lambda t}$	$F = Bqv \sin \theta$
$N = \frac{N_0}{2^x}$	$B = \frac{\mu_0 I}{2\pi a}$
$A = \frac{A_0}{2^x}$	$B = \mu_0 nI$
$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}}$	$\Phi = AB \cos \theta$
$E = mc^2$	flux linkage = $N\Phi$
$F = BIl \sin \theta$	

**OPTION A**

flux linkage = $BAN \cos \omega t$	$X_L = \omega L$
$V = \omega BAN \sin \omega t$	$X_C = \frac{1}{\omega C}$
$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$	$Z = \sqrt{X^2 + R^2}$
$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$	$Q = \frac{V_L}{V_R} \left( = \frac{V_C}{V_R} \right)$
$V_{\text{rms}} = \frac{\omega BAN}{\sqrt{2}}$	$Q = \frac{\omega_0 L}{R}$

**OPTION B**

$I = I_0 e^{-\mu x}$	$f = 42.6 \times 10^6 \text{ B}$
$Z = c\rho$	$H = DW_R$
$\frac{\Delta f}{f_0} = \frac{2v}{c} \cos \theta$	$E = HW_T$

**OPTION C**

$Ft = mv - mu$	$\tau = I\alpha$
$e = \frac{\text{Relative speed after collision}}{\text{Relative speed before collision}}$	$L = I\omega$
$e = \sqrt{\frac{h}{H}}$	$KE = \frac{1}{2}I\omega^2$
$I = \frac{2}{5}mr^2$	$p = p_0 - \frac{1}{2}\rho v^2$
$I = \frac{2}{3}mr^2$	$F_D = \frac{1}{2}\rho v^2 AC_D$
$\alpha = \frac{\omega_2 - \omega_1}{t}$	

**OPTION D**

$I = \frac{P}{A}$	$\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}$
$P = \frac{1}{2}A\rho v^3$	$P = UA\Delta\theta$

## Mathematical Information

### SI multipliers

Multiple	Prefix	Symbol
$10^{-18}$	atto	a
$10^{-15}$	femto	f
$10^{-12}$	pico	p
$10^{-9}$	nano	n
$10^{-6}$	micro	$\mu$
$10^{-3}$	milli	m
$10^{-2}$	centi	c

Multiple	Prefix	Symbol
$10^3$	kilo	k
$10^6$	mega	M
$10^9$	giga	G
$10^{12}$	tera	T
$10^{15}$	peta	P
$10^{18}$	exa	E
$10^{21}$	zetta	Z

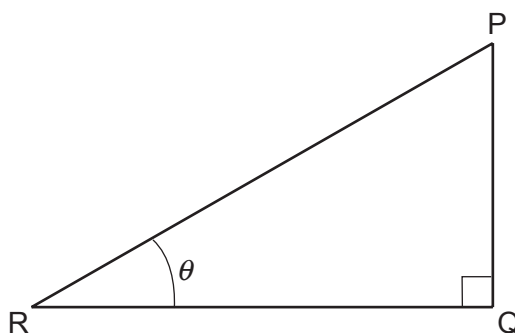
### Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	$lbh$
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3} \pi r^3$

### Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

### Logarithms (A2 only)

[Unless otherwise specified 'log' can be  $\log_e$  (i.e.  $\ln$ ) or  $\log_{10}$ .]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$

**BLANK PAGE**