



UNIT 5

From creation to collapse

REVISION NOTES

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Heat Energy

- $\Delta E = m \times c \times \theta \Delta$
- $c =$ specific heat capacity $\text{Jkg}^{-1}\text{K}^{-1}$
- Internal energy
 - Random distribution of potential and kinetic energy amongst molecules.
 - Average kinetic energy related to the absolute temperature
- For an ideal gas
$$\frac{1}{2} m \langle c^2 \rangle = \frac{3}{2} kT$$

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Equation of state

- $PV = nRT = NkT$
- Boyle's Law $PV = \text{'konstant'}$
- Charles' Law $V/T = \text{'konstant'}$
- Pressure Law $P/T = \text{'konstant'}$
- Temperature must be absolute
 - $R =$ Molar gas constant
 - $k =$ Boltzmann constant

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Radioactivity 1

- Background radiation
 - Cosmic radiation, Radon, man made.
- α particles - Helium nucleus ${}^4_2\text{He}^{2+}$ Am^{241}
 - range 5cm in air, thin sheet of paper
 - highly ionising, short straight tracks
 - Smoke detectors
 - Mass number -4, Atomic number -2
- β particles – nuclear electrons e^- Sr^{90}
 - range of energies, stopped by several mm of Al,
 - faint tracks, range of lengths
 - Mass number unchanged, Atomic number +1

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Radioactivity 2

- γ rays – em radiation – $\lambda < 10^{-10}\text{m}$ Co^{60}
 - Not emitted on its own, accompanied by α or β
 - range several cm of Pb
 - Industrial X-rays, sterilisation, radiotherapy
- 1Bq – becquerel – 1 disintegration/second

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Radioactivity 3

- Radioactive decay – random and spontaneous
 - Rate of decay \propto number of unstable atoms remaining.
- $dN/dt = -\lambda N$ $N = N_0 e^{-\lambda t}$
- Half life – time taken for half of the unstable atoms to decay

$$T_{1/2} = \ln 2 / \lambda$$
- u = atomic mass unit = mass of $1/12$ of C^{12} atom

$$u = 1.66 \times 10^{-27} \text{kg}$$
- $\Delta E = \Delta m \times c^2$ Einstein

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Radioactivity 4

- Nuclear fission
 - Splitting of large nuclei to form smaller nuclei
 - energy released owing to products being more stable
- Nuclear fusion – very large temperature
 - Combining of smaller nuclei to form larger nuclei
 - energy released owing to products being more stable
- Mass difference – Binding energy
 - Ni^{62} has the greatest binding energy

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Gravitation

- Newton's law of gravitation $F = \frac{GMm}{r^2}$
- Gravitational field strength $g = \frac{GM}{r^2}$
- Equate to centripetal force for satellites

$$mv^2/r = m\omega^2 r = GMm/r^2$$
- Electric v gravitation
 - strong, short range, attractive and repulsive
 - weak, very long range, only attractive

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Cosmology 1

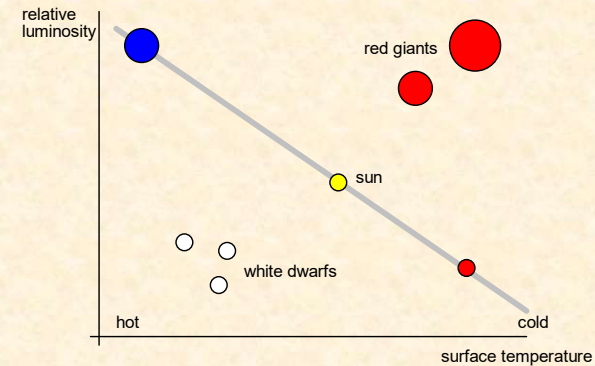
- Radiant flux = $Luminosity/4\pi d^2$
- Parallax method of finding stellar distances
 - only works for nearby stars.
- Luminosity and Cepheid variables for more distant stars – standard candles.
 - Cepheids – 4 – 20 times the mass of the sun. The period of light fluctuation is related to its intrinsic luminosity.
- Supernova – standard candles for more distant stars.

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Cosmology 2

- Hertzsprung-Russell diagram



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Cosmology 3

- Life cycle of a star
 - Hydrogen and space debris collects together owing to gravity
 - This causes the temperature to increase until fusion starts.
 - Star burns Hydrogen, then starts to expand fusing the heavier elements, forming a red giant.
 - As fuel runs out, gravitational collapse occurs leading to supernova
 - Depending on mass of star either a white dwarf, neutron star or black hole formed.

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Black body radiation

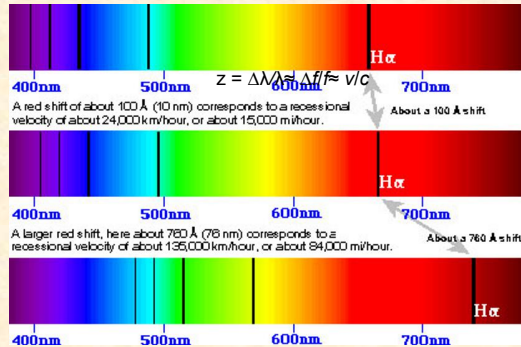
- Ultra-violet catastrophe.
- Stephan's Law $W = \sigma AT^4$
 - For a star $L = 4\pi r^2 \sigma T^4$
- Wien's Law $\lambda_{max} \times T = k = 2.898 \times 10^{-3} m.K$

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Doppler shift

- Size of red shift, $z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
 - If negative then the object is moving towards the observer.



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Hubble constant

- Edwin Hubble discovered a link between the velocity of a star (v) and its distance (d)
- $V = H_0 d$
- H_0 – Hubble constant $\approx 2.3 \times 10^{-18} \text{s}^{-1}$
- Can be used to find the distance of any stellar object.
- Some issues with predicted size and age of universe (14×10^9 years)
 - Dark matter??

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Simple Harmonic Motion 1

- Acceleration is proportional to the displacement and is directed towards a fixed point.
- $a = -\omega^2 x = -A\omega^2 \cos \omega t$
- $V = \omega \sqrt{(A^2 - x^2)} = -A\omega \sin \omega t$
- $x = A \cos \omega t$
- $T = 2\pi/\omega = 1/f$
- $\omega = 2\pi f$

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Simple Harmonic Motion 2

- Pendulum $T = 2\pi\sqrt{l/g}$
- Spring $T = 2\pi\sqrt{m/k}$
- Total energy of a SHM oscillator is constant - exchanges between PE and KE.
- Free oscillations – natural resonant frequency.
- Damped oscillations – loss of energy so oscillations die away.
- Forced oscillations – energy supplied to system
 - large amplitude when supplied at resonant frequency.

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Prefixes

| | | | |
|---------|-----------------------|-----|----------------|
| • tera | ×1,000,000,000,000 | (T) | TeV |
| • giga | ×1,000,000,000 | (G) | GeV |
| • mega | ×1,000,000 | (M) | MHz, M |
| • kilo | ×1,000 | (k) | kHz, k, kV |
| • milli | ×0.001 | (m) | mV, mA, mW |
| • micro | ×0.000 001 | (μ) | μV, μA, μW, μF |
| • nano | ×0.000 000 001 | (n) | nF |
| • pico | ×0.000 000 000 001(p) | pF | |

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Questions

- Set in context – read the context – underline relevant details.
- Look carefully at diagrams – circle and name relevant details.
- Focus on relevant bookwork descriptions and calculations – answer these.
- Attempt all sections – no credit can be given if there is no attempt at an answer!!!!!!!
- *Estimate, Calculate* – show your working.
- *State and explain* – do both!

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Notes

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Notes

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