# Lessons 1 - 2

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| 1. | (a) | Calculate the kinetic energy and momentum of a 60 g tennis ball moving at 25 ms-1 |
|  | (b) | Calculate the kinetic energy and momentum of an electron moving at 100 ms-1 (the mass of an electron is 9.1 x 10-31 kg) |
| 2. | (a) | Calculate the wavelength of Radio Democracy waves, which are emitted with a frequency of 98.1 MHz |
|  | (b) | Calculate the frequency of a microwave with wavelength 1 cm |
| 3. | (a) | Calculate the energy of a photon of green light of wavelength 522 nm |
|  | (b) | Calculate the energy of an X-ray photon of wavelength 50 pm |
| 4. |  | The energy required to remove an electron from lithium is 276 kJmol-1 |
|  | (a) | Calculate the minimum frequency of light required to cause photoelectric emission in lithium |
|  | (b) | Calculate the maximum possible velocity of an electron emitted when light of frequency 7.3 x 1014 Hz is used for photoelectric emission in lithium |
|  | (c) | The longest wavelength capable of causing photoelectric emission in aluminium is 3.03 x 10-7 m; calculate the molar energy required to remove an electron from aluminium |
|  | (d) | Calculate the momentum of a photon of green light of wavelength 522 nm |
|  | (e) | Explain briefly how the Compton effect and the Photoelectric effect provide evidence that waves can behave as particles |
| 5. | (a) | Calculate the minimum uncertainty in the position of a 0.40 kg football if the uncertainty in its momentum is 16 kgms-1 |
|  | (b) | Calculate the minimum uncertainty in the position of an electron is the uncertainty in its momentum is 1.6 x 10-8 kgms-1 |
|  | (c) | Explain the importance of the Davisson-Germer experiment in developing the theory of wave-particle duality of matter |
| 6. | (a) | Calculate the de Broglie wavelength of an electron moving at 100 ms-1 |
|  | (b) | Calculate the de Broglie wavelength of a 60 g tennis ball moving at 5 ms-1 |

# Lessons 3 - 4

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| 1. | (a) | Describe how atoms produce emission spectra |
|  | (b) | State the postulate used by Bohr to describe how electrons were quantised in an atom |
|  | (c) | Use this postulate to show that the value of the Rydberg constant in a hydrogen atom should be 1.10 x 107 m-1. |
|  | (d) | Deduce the value for the Rydberg constant in a He+ ion |
| 2. | (a) | Use the value of RH given in 1(c) to calculate the wavelength of light emitted as a result of the following transitions: |
|  |  | (i) | n = 3 to n = 1 |
|  |  | (ii) | n = 5 to n = 2 |
|  | (b) | Calculate the energy required, in kJmol-1, to remove an electron completely from its ground state in a hydrogen atom |
| 3. | How did de Broglie and Sommerfeld improve on the Bohr model of the atom? |

# Lesson 5

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| 1. | Three dimensional classical standing waves are known to satisfy the following differential equation: $∇$**2**ψ = -$\frac{4π^{2}}{λ^{2}}$ ψ |
|  | (a) | Explain the meaning of the terms $∇$**2**ψ, ψ and λ in this equation. |
|  | (b) | From this equation, derive the Schrodinger equation for ψ in terms of m, E and U and explain the meaning of these terms. |
|  | (c) | Hence explain how the Schrodinger equation contains both a wave component and a particle component. |
| 2. | (a) | What is the significance of the term ψ2? |
|  | (b) | What is the general expression for the value of U in an atom containing only one electron? How must this expression be adapted to allow for multi-electron atoms? |
|  | (c) | What are polar coordinates? What do the terms “radial component” and “angular component” of a wavefunction mean? What information can be found by finding the real solutions to these components? |
| 3. | (a) | List all the different combinations of l and ml possible if n = 3. |
|  | (b) | Hence explain how many electrons can be placed in the third energy level of an atom. |
|  | (c) | Explain the meaning of the terms “degenerate” and “node”. |

# Lesson 6

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| 1. | Using valence bond theory, draw Lewis-dot structures for, state the type of hybridisation in, draw the shapes for and state the approximate bond angles in the following molecules and ions: |
|  | (a) | SO3 |
|  | (b) | SO2 |
|  | (c) | SO42- |
|  | (d) | SO32- |
|  | (e) | SF6 |
|  | (f) | PCl3 |
|  | (g) | PCl5 |
|  | (h) | NO3- |
|  | (i) | NO2- |
|  | (j) | ClF3 |
|  | (k) | IF5 |
|  | (l) | IO3- |
|  | (m) | ClO2- |
|  | (n) | XeF2 |
|  | (o) | XeF4 |
| 2. | Sketch a graph to show the relationship between potential energy and internuclear distance. Identify the bond length and the bond energy from this graph. |