Q15 [*Electronic structure of atoms*] The first ionization energy of rubidium is approximately 4.2 eV. What are the quantum numbers of the electron whose removal from the rubidium atom in its ground state requires 4.2 eV of energy? Choose from A–D in the key the value of n and from E–H the letter corresponding to the value of l. Pencil across *two* cells in row 15.

KEY for Q15

A 2	E s
B 3	F p
C 4	G d
D 5	H f

look up 'first ionisation energy'

PART E

The questions in this part relate to Unit 16.

Q16 [*Exclusion principle*] The key lists a number of electrically neutral particles, using the notation ${}^{A}_{Z}X$ for an isotope of element X with mass number A and atomic number Z. Which *two* particles in the key are not subject to the (generalized) exclusion principle? Pencil across *two* cells in row 16.

KEY for Q16

A A carbon monoxide molecule (${}^{12}_{6}C + {}^{16}_{8}O$).

B An atom of the helium isotope ${}^{3}_{2}He$.

C A nitric oxide molecule (${}^{14}_{7}N + {}^{16}_{8}O$).

D A beryllium atom ${}^{9}_{4}Be$.

E A nitrogen atom ${}^{14}_{7}N$.

F A lithium atom ${}^{7}_{3}Li$.

G A beryllium oxide molecule (${}^{9}_{4}Be + {}^{16}_{8}O$).

Q17 [*Exclusion principle*] The key contains seven facts that rely on quantum mechanics. Which *one* of these facts is most closely related to the fact that no two fermions can share the same set of quantum numbers? Pencil across *one* cell in row 17.

KEY for Q17

A A laser can produce an intense narrow beam of monochromatic light.

B At temperatures very close to absolute zero (0 K), liquid ^{4}He is a superfluid; it is able to flow unimpeded through very narrow channels and exerts no drag force on slowly moving solid objects.

C The scanning tunnelling microscope is based on the quantum mechanical phenomenon of tunnelling.

D Electron waves can be diffracted by tiny crystals in a sample of ceramic placed under an electron microscope.

E The sun burns its nuclear fuel (hydrogen nuclei) very gradually because protons can only coalesce by overcoming the strong coulomb repulsion — a process that occurs mainly by quantum mechanical tunnelling.

F When the core of a typical red giant runs out of fuel it collapses to form a white dwarf — a stable star with a mass comparable to the Sun and a radius comparable to the Earth.

G The pulses from a rapidly rotating neutron star are almost regular but sometimes display occasional 'glitches'.

Q18 [*White dwarf stars*] The Fermi energy of the electrons in a cold white dwarf star is 8.0×10^{-11} J. Estimate the Pauli pressure exerted by these electrons, and select the option from the key that is closest to your estimate. Pencil across *one* cell of row 18.

KEY for Q18

A 10^{6} N m^{-2}	E 10^{30} N m^{-2}
B 10^{12} N m^{-2}	F 10^{36} N m^{-2}
C 10^{18} N m^{-2}	G 10^{42} N m^{-2}
D 10^{24} N m^{-2}	H 10^{48} N m^{-2}

$E = \frac{h^2}{8m}(N/V)^{2/3}$ $(N/V)^{2/3} = \frac{8mE}{h^2}$

$(N/V) = \sqrt{\left(\frac{8mE}{h^2}\right)^3}$

$P = \frac{h^2}{20mE}\sqrt[3]{\left(\frac{8mE}{h^2}\right)^5}$

$P = \frac{2N}{3V} \times \frac{3}{5} E_{max} = \frac{2}{5V} N E_{max}$

$\left(\frac{N}{V}\right)^{2/3} = \frac{8mE_{max}}{h^2} =$