2.1 Atomic Structure: 30-minute Pack

AQA 7405 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question is about the sub-atomic particles found in atoms and ions, and the concept of isotopes.

(a) Complete the table below to show the relative mass and relative charge of a proton, a neutron and an electron. **(3)**

Particle	Relative mass	Relative charge
Proton	1	+1
Neutron	...	...
Electron	...	...

(b) Define the term isotopes. **(1)**

(c) Chlorine exists naturally as two isotopes, 35Cl and 37Cl. Chlorine has atomic number 17. State the number of protons, neutrons and electrons in one atom of 37Cl. **(3)**

(d) 35Cl and 37Cl are chemically identical to one another but can have slightly different physical properties, such as density. Explain why. **(2)**

(Total for Question 1 is 9 marks)

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2 This question tests key definitions and facts about atomic structure. For each part, identify the correct option.

(a) Potassium-39 has atomic number 19. Which row correctly gives the number of protons and neutrons in one atom of potassium-39? **(1)**

- ☐ A) 19 protons, 19 neutrons
- ☐ B) 19 protons, 20 neutrons
- ☐ C) 20 protons, 19 neutrons
- ☐ D) 39 protons, 19 neutrons

(b) Which statement correctly defines the relative atomic mass of an element? **(1)**

- ☐ A) The mass of one atom of the element compared with the mass of one atom of hydrogen-1.
- ☐ B) The average mass of all the isotopes of the element compared with the mass of one atom of carbon-12.
- ☐ C) The weighted mean mass of the isotopes of an element compared with 1/12 the mass of one atom of carbon-12.
- ☐ D) The mass number of the most abundant isotope of the element.

(c) How many orbitals are there in total within a p sub-shell? **(1)**

- ☐ A) 1
- ☐ B) 2
- ☐ C) 3
- ☐ D) 5

(d) Which ionisation method is typically used in a modern time-of-flight mass spectrometer to ionise large or delicate molecules without breaking them apart? **(1)**

- ☐ A) Electron impact ionisation
- ☐ B) Electrospray ionisation
- ☐ C) Thermal ionisation
- ☐ D) Flame ionisation

(Total for Question 2 is 4 marks)

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3 This question is about atomic orbitals and sub-shells.

(a) State the maximum number of electrons that can occupy: (i) a single atomic orbital, (ii) an s sub-shell, (iii) a p sub-shell. **(3)**

(b) State the number of orbitals within a p sub-shell and describe their shape and relative orientation to one another. **(2)**

(c) Nitrogen has the electron configuration 1s2 2s2 2p3. Complete a diagram of boxes to show how the three 2p electrons are arranged within the three 2p orbitals, and use Hund's rule to explain the arrangement you have shown. **(3)**

2p: [ ] [ ] [ ]

(Total for Question 3 is 8 marks)

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Mark scheme · 2.1 Atomic Structure: 30-minute Pack

Question 1

(a) neutron: relative mass 1 AND relative charge 0 **B1**

(a) electron: relative mass 1/1840 (accept approx 0.00055 or 5.5×10^{-4} or 'negligible') **B1**

(a) electron: relative charge -1 **B1**

(a) Answer: Neutron: mass 1, charge 0. Electron: mass 1/1840 (approx 0.00055), charge -1.

(b) atoms of the same element (same number of protons/same atomic number) with different numbers of neutrons (different mass numbers) oe **B1**

(b) Answer: Atoms of the same element with the same number of protons but different numbers of neutrons.

(c) protons = 17 **B1**

(c) neutrons = 20 **B1**

(c) electrons = 17 **B1**

(c) Answer: Protons = 17, neutrons = 20, electrons = 17.

(d) chemical properties depend on the number and arrangement of electrons, which is identical for both isotopes (same atomic number) oe **B1**

(d) physical properties (e.g. density) depend on the mass of the atom, which differs because the isotopes have different numbers of neutrons (different mass numbers) oe **B1**

(d) Answer: Isotopes have identical electron arrangements so identical chemical properties, but different numbers of neutrons give different masses, so physical properties differ slightly.

Question 2

(a) B **B1**

(a) Answer: B

(b) C **B1**

(b) Answer: C

(c) C **B1**

(c) Answer: C

(d) B **B1**

(d) Answer: B

Question 3

(a) (i) 2 **B1**

(a) (ii) 2 **B1**

(a) (iii) 6 **B1**

(a) Answer: Orbital: 2. s sub-shell: 2. p sub-shell: 6.

(b) 3 orbitals (px, py, pz) **B1**

(b) each is dumbbell (figure-of-eight) shaped, and the three orbitals are oriented at right angles (90 degrees) to each other along the x, y and z axes oe **B1**

(b) Answer: 3 orbitals, each dumbbell-shaped, arranged at 90 degrees to one another along the x, y and z axes.

(c) three separate 2p boxes each shown with a single (unpaired) arrow, all pointing the same direction (no pairing shown) **M1**

(c) states Hund's rule: electrons occupy separate orbitals of equal energy (degenerate orbitals) singly, with parallel spins, before any pairing occurs oe **B1**

(c) this arrangement minimises the repulsion between electrons, giving a more stable (lower energy) configuration oe **B1**

(c) Answer: 2p: one electron in each of the three 2p orbitals, all spins parallel (up, up, up).

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