Worksheet 4 - Ions, Isoelectronic Species and Chemical Identity

Trimester school assessment - IB-style chemistry practice

Suggested time: 50 minutes	**Total marks:** 44	**HL:** Includes one HL comparison of chemical and physical identity.

Learning focus

- Distinguish atoms, cations and anions.
- Identify isoelectronic species.
- Explain why electrons control chemical properties while protons identify the element.

Section A - Multiple choice

Q1. A positive ion is formed when an atom:

A gains protons
B loses protons
C gains electrons
D loses electrons

Q2. Which ion is an anion?

A Ca^2+
B Al^3+
C Cl^-
D K^+

Q3. Which pair is isoelectronic?

A Na and Mg
B Ne and Na^+
C Cl and Cl^-
D Ca^2+ and K

Q4. Sodium atoms and sodium ions differ mainly in their number of:

A protons
B neutrons
C electrons
D nucleons

Q5. Which species has 10 electrons?

A F^-
B Mg
C Al^3-
D O

Q6. During ordinary chemical reactions, which subatomic particles are transferred or shared?

A protons
B neutrons
C electrons
D nucleons

Section B - Short answer

Q7. Explain why Na and Na^+ have different chemical behaviour although both contain 11 protons. **[3]**

Q8. Complete the table for common ions. **[8]**

Ion	Protons	Electrons	Charge type	Electrons lost/gained
Mg^2+				
O^2-				
Al^3+				
S^2-				

Q9. Give two examples of species with 18 electrons and state their charges. **[3]**

Section C - Data response/case study

A solution contains several dissolved ions important in nutrition and health.

Ion	Mass number	Atomic number	Charge
Calcium ion	40	20	2+
Potassium ion	39	19	1+
Chloride ion	35	17	1-
Phosphate ion (P only considered)	31	15	3-

Q10. Deduce the number of protons, neutrons and electrons for each ion. **[8]**

Q11. Identify which ions are isoelectronic with argon, Ar. Argon has 18 electrons. **[3]**

Q12. Explain why the mass number is unchanged when an atom becomes an ion. **[2]**

Section D - Extended response and HL extension

Q13. A student says: "An ion is a new element because its properties change." Evaluate this statement using subatomic particles. **[7]**

Q14. HL: The ions ^40Ca^2+ and ^40Ar are isoelectronic. Compare their chemical identity, nuclear charge and expected behaviour in an electric field. **[4]**

Answer key and marking guidance

Award marks for chemically correct ideas. Accept alternative wording when the same scientific meaning is clear. For extended responses, use the marking guidance as a best-fit rubric.

Q1-6. D, C, B, C, A, C. MC: 1 mark each.

Q7. Both have 11 protons so both are sodium [1]. Na has 11 electrons but Na+ has 10 [1]. Different electron arrangement/charge gives different chemical behaviour/reactivity [1].

Q8. Mg2+: 12 p, 10 e, cation, lost 2 [2]; O2-: 8 p, 10 e, anion, gained 2 [2]; Al3+: 13 p, 10 e, cation, lost 3 [2]; S2-: 16 p, 18 e, anion, gained 2 [2].

Q9. Any two correct examples: Ar, Cl-, K+, Ca2+, S2-. Include charges. [3]

Q10. Ca2+: p20 n20 e18 [2]; K+: p19 n20 e18 [2]; Cl-: p17 n18 e18 [2]; P3-: p15 n16 e18 [2].

Q11. Ca2+, K+, Cl- and P3- each have 18 electrons; all are isoelectronic with argon. Award [3] for any three correct or [3] for all listed.

Q12. Mass number is protons + neutrons [1]. Ion formation changes electrons only, not protons or neutrons [1].

Q13. Best-fit [7]: statement is incorrect in terms of identity because element is defined by proton number [2]; ion formation changes electrons [1]; charge changes because p and e no longer balance [1]; chemical properties may change strongly [1]; mass number/nucleus unchanged [1]; clear example such as Na/Na+ or Cl/Cl- [1].

Q14. HL: They both have 18 electrons [1] but different nuclear charges: Ca has 20 p and Ar has 18 p [1]. They are different elements because proton number differs [1]. In an electric field Ca2+ is deflected/attracted as a positive ion, while neutral Ar is not deflected significantly [1].