

Chemguide – answers

TRANSITION METALS: GENERAL FEATURES

1. a) (i) $[\text{Ar}]3d^{10}4s^1$
(ii) $[\text{Ar}]3d^24s^2$
(iii) $[\text{Ar}]3d^{10}4s^2$
(iv) $[\text{Ar}]3d^54s^1$
- b) (i) $[\text{Ar}]3d^6$
(ii) $[\text{Ar}]3d^5$
(iii) $[\text{Ar}]3d^2$
(iv) $[\text{Ar}]3d^8$
(v) $[\text{Ar}]3d^9$

If you got anything wrong in parts (a) and (b), get it sorted! You can't afford to waste easy marks in an exam. If you get this sort of basic stuff wrong, it could easily make it impossible to answer the rest of a question properly as well.

2. The d-block elements (or metals – they are all metals) are those where the d levels are filling from d^1 to d^{10} . In the first row, those are the elements from scandium to zinc.

There are two possible definitions of transition metals. Use whichever one your examiners want.

- A transition metal is one which forms one or more ions with partially filled d orbitals. That would exclude scandium which only forms $3+$ ions with the 3d level empty, and zinc which only forms $2+$ ions with the 3d level full.
- A transition metal is one which has partially filled d orbitals either in the metal or one or more of its ions. This includes scandium because it has a partially filled 3d level in the metal, but excludes zinc, where the 3d level is always full.

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3. a) Any two of:

+2	in Mn^{2+}
+3	in Mn_2O_3
+4	in MnO_2
+6	in MnO_4^{2-}
+7	in MnO_4^-

If you choose any other examples, you will have to check them against your source.

b) (i) The ionisation energy is only one of a number of energy steps involved in forming compounds containing the ions, although it is the most important energy input term. Energy is then released when the positive ions form a lattice with whatever negative ions are involved (lattice enthalpy), or by bonding with water if a solution is being formed (hydration enthalpy). In both of these cases, the more highly the positive ion is charged, the more energy is released.

To form a 2+ ion needs more ionisation energy, but the gain in lattice enthalpy or hydration enthalpy with the 2+ ion more than compensates for this. The overall effect is that more energy is released if a 2+ ion is formed than a 1+, and so the 2+ ion is the more stable.

(ii) The third ionisation energy of calcium is much greater than the third ionisation energy of iron. In the calcium case, the gain in lattice enthalpy or hydration enthalpy in forming the 3+ ion isn't enough to compensate for the higher ionisation energy. In the iron case, it is.

The reason for the bigger jump in the third ionisation energy of calcium is that the electron is being removed from a level closer to the nucleus (from a 3p orbital rather than the 4s orbital that the first two electrons come from). In the case of iron, the third electron is coming from a 3d orbital which has an energy which is similar to the 4s orbital which is where the first two electrons came from.

4. a) ligands

b) By co-ordinate (dative covalent bonds) between lone pairs on the ligands and empty orbitals on the metal ion.

c) $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ pale blue

$[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ very dark blue

(If you got this wrong, don't worry about it unless you have already done some copper chemistry, or a complex ions topic. If you *have* done these, then a certain amount of panic might be necessary!)

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5. a) iron
b) nickel
c) vanadium(V) oxide (vanadium pentoxide)