C2 – Atomic Structure

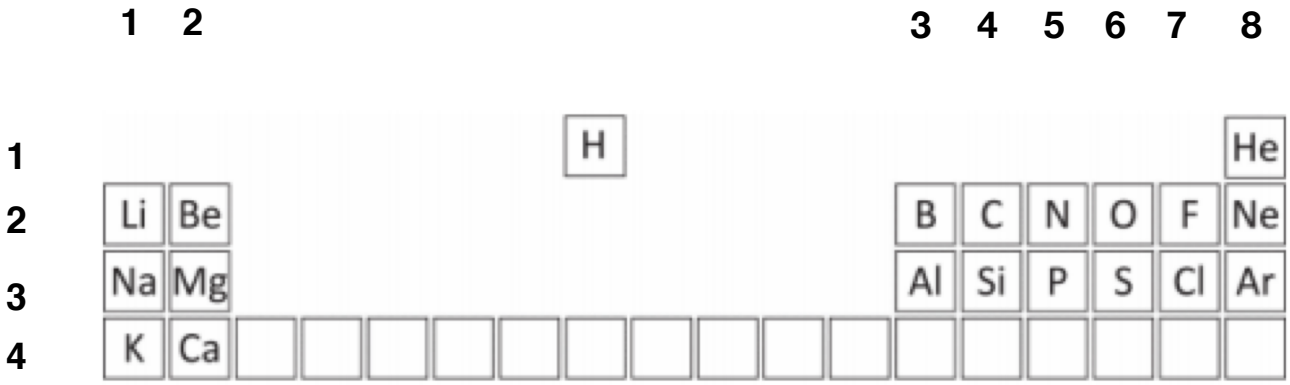
2016 Q2 – the correct answer is F: Statements 2, 3 and 4 are correct only.
Statement 1 is incorrect: A group of an element tells you the number of outer electrons, hence the element cannot be in group 12, as there are only 3 electrons in its outer shell. In a period, the number of electron shells are the same, and the period number is determined by the number of electron shells. Period 3 is correct, however, Group 12 is not.
Statement 5 is incorrect: Alkali metals occupy group 1 in the periodic table – they only have 1 electron in their outermost shell. Whereas, element X is in Group 3.
Statement 4 is correct: The atomic number is the number of protons, which is also the number of electrons, in the atom. Adding up the electrons in the 3 shells:
2 + 8 + 3 =13.
Statement 3 is correct: Bromine is in Group 7, hence has 7 electrons in its outermost shell. It needs 1 electron to complete its shell, which can hold a maximum of 8 electrons. Element X can give 3 electrons to gain a complete shell, which is composed of 8 electrons - below the outermost shell. Hence, X donates 1 electron each to 3 Bromine atoms, forming XBr_3.
Statement 2 is correct: Oxygen is in Group 6, hence it has 6 electrons in its outermost shell – requiring 2 electrons to complete its shell. Element X has 3 electrons, and so one electron will remain spare! However, to resolve this issue, a **lowest common multiple (LCM)** of 2 and 3 must be found 6.
If there are 2X atoms, they have 6 electrons in total. If there are 3O atoms, they have 18 electrons in total. One X atom can give 2 electrons to each O atom. Hence, the formula is X_2O_3.

2016 Q7 – the correct answer is D: Statements 1 and 2 are correct. Isotopes have the same chemical properties, as they have the same atomic number. The atomic number dictates how many protons occupy the atom, which is also the same number as the electrons. If the electron number is the same, then the isotopes will have the same chemical properties. Statement 3 is incorrect: Beware, the question only gives mass numbers, **not** neutron numbers. Mass number = atomic number + number of neutrons. Hence, Statement 3 can be corrected by: 62 – 28 = 34. Hence, one of them has a nucleus containing 34 neutrons.

2015 Q22 – the correct answer is C: For this question, you must calculate the electron number of each ion/element given. This can be found on the atomic number. The charges – positive and negative – change the electron numbers from their elements, as these elements have been ionised. If the atom is negatively charged,

add 1 electron to the atomic number, and if the atom is positively charged, subtract 1 from the atomic number.
Cl- : 17 + 1 = 18 ; Cl+ : 17 – 1 = 16 ; Ar : 18 ; K+ : 19 – 1 = 18, Ca+: 20 – 1 = 19, K- : 19 + 1 = 20
Hence, Cl- , Ar and K+ have the same electron arrangement: 18 electrons.

2013 Q14 – the correct answer is A: In order to simplify this question, you are given a part of the periodic table. Firstly, assign the groups and periodic numbers, in order to find out the electron numbers. The columns are the group numbers, and the rows are the periods



The elements in question are: C, Mg, Cl, N, H, O, F, Ar and Ne. Carbon is in group 4, (4 outer electrons) and period 2 – hence, 2 shells. As maximum of 2 in innermost shell, C has: (2, 4) 2 + 4 = 6 electrons.
Mg: Mg is in Group 2, Period 3. Hence, 2, 8, 2 2 + 8 + 2 = 12 electrons
Cl: Group 7, Period 3. Hence, 2, 8, 7 2 + 8 + 7 = 17 electrons
F: Group 7, Period 2. Hence, 2, 7 2 + 7 = 9 electrons
N: Group 5, Period 2. Hence, 2, 5 2 + 5 = 7 electrons
H: Group 1, Period 1. Hence, 1 electron
O: Group 6, Period 2: 2, 6 2 + 6 = 8 electrons
Ar: Group 8, Period 3: 2, 8, 8 2 + 8 + 8 = 18 electrons
Ne: Group 8, Period 2: 2, 8 2 + 8 = 10 electrons

C3 – Separation

2016 Q6 – the correct answer is E: Ethanol and water **cannot** be separated by a separating funnel. This is as, ethanol is **soluble** in water, as it forms hydrogen bonds with water molecules. Hence, distillation can separate them.

2013 Q2 – the correct answer is D: A displacement reaction will occur in 1 and 4 only. This is as, Aluminium is more reactive than Lead (Pb), and so will displace Ph from $Pb(NO_3)$. It is more reactive, as Al is in Group 3, whereas Pb is in Group 4. Hence, Al has less electrons in its outer shell, which can overcome nuclear attraction be lost easily, compared to lead which has more electrons, hence has to overcome a higher nuclear attraction.
Zn (Zinc) is more reactive than Cu (Copper). This is as, for the same amount of shielding, (this is the number of electron shells, and as they are both in Period 4, they have the same number of shells – 4 shells) Zn has one more electron than Cu. The outermost electrons in both elements are in the 4s orbital. Zn has 2 electrons in the 4s orbital, whereas Cu only has 1 electron. Hence, Zn can easily lose these 2 electrons in the 4s orbitals for the same amount of shielding, compared to Cu.

2012 Q6 – the correct answer is C: The head is hydrophobic, which repels water and ionic substances. The tail is hydrophilic, as it is attracted to water and ions soluble in water. This is as, the oils are larger than water in size, and so a large surface area, the hydrophobic head, attracts these oils. Water molecules, which are present in a higher quantity due to their size, cluster around the tail in abundance. This forms an emulsion of oil and water, as the molecule is classified as an emulsifier.

C4 – Calculations

2016 Q10 – the correct answer is F: To calculate the mass, the mass numbers of all elements are needed. Hence (in order of the formula):
$2(14 + 4(1)) + 56 + 2(32 + 4(16)) + 6(2(1) + 16) = 36 + 56 + 192 + 108 = 392$

2016 Q18 – the correct answer is E: As the acid is **diprotic**, and NaOH neutralises the acid, **2 moles of NaOH** are needed.
$n = c \times v \times 10^{-3}$ n (Diprotic) $= 30 \times 0.2 \times 10^{-3} = 0.006$
As 2 NaOH, n(NaOH) $= 2 \times 0.006 = 0.012$
For base (NaOH): $v = (n/c) \times 1000$ $v = (0.012/0.1) \times 1000 = 120\ cm^3$

2016 Q26 – the correct answer is D: $2X + Y \rightarrow 2Z$. There is a 1:1 mole ratio between X and Z, and as moles are proportional to volume (in n=cv), the volume of X and Z must be the same. The question states, that 2X and Y react together to form a compound which has the same moles as X. Hence, the final volume of Z is 100 cm^3 too.

2015 Q26 – the correct answer is B: To answer this question, firstly, work out the moles on the CH_4.

$n(CH_4) = m/Mr = 1.6/(12+4) = 0.1$

$CH_4:2H_2O$ – ratio of 2:1 (compare these ratios, as the mass of water is unknown)

Hence, moles of water = 2 x 0.1 = 0.2

Mass of water = n x Mr(water) = 0.2 x 18 = 3.6

Form an equation of mass, where (8-x) represents the quantity of **reacted oxygen;** x = **unreacted oxygen**

Hence: 1.6 + (8 – x) = 4.4 + 3.6

1.6 + 8 – x = 8

Hence, x = 1.60g.

2014 Q18 – the correct answer is B:

You **need** to find: the molecular mass, from the mass, volume and mole information, and then dividing this mass over the 3 elements to figure out how many atoms of each are present in the molecule.

Using the molar gas volume given (1 mole = $24dm^3$), we can deduce that 2.4 dm^3 of the compound must contain 0.1 moles.

Hence, 0.1 moles of the compound weighs 6g. So, 1 mole of the compound would weigh 60g.

Hence the relative molecular mass must be 60.

The ratio of C : H : O by mass is 6 : 1 : 8; dividing the mass into this ratio gives us the mass of each element in the molecule. C: 6 15 × 60 H: 1 15 × 60 O: 8 15 × 60

The relative masses are: C: 24 H: 4 O: 32 Using the Ar values, we can see this relates to 2 carbons, 4 hydrogens, and 2 oxygens. The molecular formula is $C_2H_4O_2$

2013 Q10 – the correct answer is B:

The equation reaction is: $2Na + H_2O \rightarrow Na_2O + H_2$

Mole ratio of $2Na:H_2 = 2:1$

$n(Na) = m/Mr = 1.15/23 = 0.05$

Hence, H_2 is 1/2 x 0.05 = 0.025

1 mole of any gas has $22.4dm^3$

Hence, 0.025 x 22400 cm^3 = 560 cm^3

2013 Q18 – the correct answer is E: To calculate percentage purity, we must compare the moles of NaOH and HCl.

$n(HCl) = c \times v \times 10^{-3} = 50 \times 0.5 \times 10^{-3} = 0.025$

The moles of NaOH and HCl are both the **same** as they **completely** react with each other.

Hence, n(NaOH) = m/Mr = 1.2/(23+1+16) = 0.03

Percentage purity: n(reacted)/n(NaOH) x 100 → 0.025/0.03 x 100 = 83.3%

2011 Q22 – the correct answer is D: Firstly, calculate the amount of PbS in the ore:
0.7 X 478 = 334.6 kg.
Find the percentage of molar mass of Pb in PbS:
Ar(PbS) = 207 + 32 = 239
The percentage of Pb = 207/239
Amount of Pb extracted: 207/239 X 334.6 = 289.80 kg.

2012 Q2 – the correct answer is D: To calculate the theoretical yield, as percentage yield = actual/theoretical x 100, it must be noted that the mole ratio of 1-bromobutane : butan-1-ol is 1:1. Hence, calculate the moles of 1-bromobutane:
n(1-bromobutane) = m/Mr = 2.74/ (4(12)+9(1)+80) = 0.02
0.02 is in the same moles as butan-1-ol. Hence, molar mass of butan-1-ol:
Mr (butan-1-ol): 4(12) + 9(1) + 16 + 1 = 74
Mass (butan-1-ol): 0.02 x 74 = 1.48
Hence, 1.11/1.48 x 100 = 75%
Ignore sodium at all costs – they have given its Ar to trick you. Sodium is in excess, and it is not the compound which partakes in either reacting species – 1-bromobutane nor butan-1-ol!

2010 Q2 – the correct answer is E: First, we need to calculate the moles of each element. Then, we need to compare their mole ratios to find the Relative Molecular Formula (RFM).
n(I) = 63.5/127 = 0.5 ; n(O) = 20/16 = 1.25
0.5 : 1.25 1/2 : 5/4 (multiply by 4 on both sides) 2:5 ratio
Hence, 2I and 5O. Hence, the formula is: I_2O_5

2010 Q6 – the correct answer is D:
2nd equation : $CO_2 + C \rightarrow 2CO$
3rd equation : $3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$
Multiply the 3rd equation by 3 to give:
$2CO + 2/3\ Fe_2O_3 \rightarrow 4/3Fe + 2CO_2$
12 C g represents 1 mole of C
The molar mass of CO_2 is : $Mr(CO_2) = 12 + 16(2) = 44$
CO_2:2CO 1:2 mole ratio
$2CO : 2CO_2$ 1:1 mole ratio
1 mole of C gives 2 moles of CO_2
Hence, 2 x 44 = 88 g of CO2

2010 Q22 – the correct answer is C: To calculate the theoretical yield, as percentage yield = actual/theoretical x 100, it must be noted that the mole ratio of benzene : nitrobenzene is 1:1. Hence, calculate the moles of benzene:
n(benzene) = m/Mr = 3.9/ (6(12)+6(1)) = 0.05
0.05 is in the same moles as nitrobenzene. Hence, molar mass of nitrobenzene:
Mr (nitrobenzene): 12(6) + 5 + 14 + 16(2) = 123
Mass (nitrobenzene): 0.05 x 123 = 6.15
Hence, 3.69/6.15 x 100 = 60%

2009 Q10 – the correct answer is E: Mr (CO_2) = 12 + 2(16) = 44
Ratio of C:Mass of CO_2 = 12/44 = 3/11
Hence, 4.77g of CO_2: 3/11 x 4.77 = 1.3g of C
For 2g of Carbon (Percentage by mass): Mass/Actual x 100 = 1.3/2 x 100 = 65%

2009 Q18 – the correct answer is C: In CH_2BrCl, the CH_2 will be constant. Hence, Ar (CH_2) = 12 + 2 = 24.
Hence, the variant part is: 128 – 24 = 104
To get 104, the only combination is: 25 + 79 = 104
There is ½ chance of 79 – Br isotope, and ¾ chance of getting the 35 – Cl isotope. As they are **independent**, multiply the fractions together, as they are probabilistic quantities: ½ x ¾ = 3/8

C5 – Electrolysis

2016 Q14 – the correct answer is C:
The electrolysis of an aqueous solution of potassium sulfate using inert electrodes produces hydrogen at the cathode and oxygen at the anode and a neutral solution of sodium sulfate remains unaltered by the electrolysis. This is as, **inert electrodes** are used. Hence, it cannot be A, B, or D as they produce a metal at the electrodes. For this to occur, the electrodes must be of that metal i.e. Copper electrodes with $CuSO_4$ would lead to copper being deposited on the electrodes.

Anode half equation (At the positive electrode, negatively charged ions lose electrons. This is **oxidation**.) : $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

Hence, oxygen is formed at the anode.

Cathode half equation (At the negative electrode, positively charged ions gain electrons. This is **reduction**.) : $4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$

Hence, hydrogen is formed at the cathode.

C7 – Reactions and Elements

2015 Q10 – the correct answer is D:

A Rubidium and chlorine are formed when an aqueous solution of rubidium chloride is electrolysed. – This statement is too vague, as it does not specify whether the electrodes are inert or of a suitable metal. If the metal is Rubidium, Rubidium will form. However, if it's a metal of higher reactivity, i.e. Francium or Caesium, they will form.

B Rubidium has higher melting and boiling points than sodium. – This is incorrect, as Rubidium has **lower** melting and boiling points than sodium. This is as, when moving down the group 1 elements, the atomic size increases, leading to the decrease of nuclear force of attraction. This is as, there are more shells shielding the nuclear attraction from the outermost electron, which is lost more easily for delocalisation. Hence, less energy is required to overcome the attraction between the loosely bound electrons and rubidium ions. Hence, the boiling and melting points are low.

C Rubidium reacts more slowly with water than sodium, forming hydrogen gas. – This is incorrect, as rubidium reacts **more vigorously, violently** and almost instantaneously in water. It does form hydrogen gas; it's more reactive than sodium.

D Rubidium is stored under oil. – This is correct, as exposure to air causes instantaneous ignition, forming rubidium oxide and oxygen. To prevent this, it is stored under oil, as with most group 1 alkaline metals.

E Rubidium sulfate has the formula $RbSO_4$ – Rubidium is a group 1 element, hence it has only 1 electron in its outermost shell. When ionised, it forms Rb^+ Whereas, the charge on SO_4 is -2: SO_4^{2-}. Hence, the formula is rather: Rb_2SO4

2012 Q14 – the correct answer is F: $CuCO_3 + Cu(OH)_2$?

Firstly, write down the quantities of each element on the LHS:

Cu = 2, C = 1, O = 5, H =2. As O =5, it cannot be A as this only has 4 O. This ratio is insufficient to answer the question.

Hence, observation of the answers is required. All answers have Cu_3.

That means that, a coefficient of 2 must be added to either $CuCO_3$ or $Cu(OH)_2$. If the 2 is on $Cu(OH)_2$, the answer can be E or F only, as the number of O = 7 now, excluding all other answers. Hence, let's try to add 2 to $CuCO_3$.

$2CuCO_3$ hence, Cu = 2, C = 2, O = 6

Combining with $Cu(OH)_2$, Cu = 1, O = 2 and H=2

The final balanced equation is: $2CuCO_3 + Cu(OH)_2$ $Cu_3C_2H_2O_8$

2010 Q18 – the correct answer is B: For this question, the hydrogen and phosphates need to be considered first. For a neutral compound, Mg^{2+} needs to balance with a -2 charge. H^+ and PO_4^{3-} : 2H+ and PO_4^{3-} would give an overall of -1 charge (as (+2) + (3-) = -1), hence H_2PO_4. To get an a -2 charge, we need $2H_2PO_4$. Hence, $(H_2PO_4)_2$. This -2 charge balances out with Mg^{2+}, giving a neutral compound. Hence, $Mg(H_2PO_4)_2$.

C8 – Organic

2015 Q14 – the correct answer is C:
A They have the general formula C_nH_{2n+2} – This is incorrect, as although they are alkanes, they are cyclic. Alkanes obey the formula C_nH_{2n+2}, whereas cycloalkanes obey C_nH_{2n}.
B They react rapidly with bromine water – This is incorrect, as alkenes react with bromine water, through electrophilic substitution, due to being unsaturated compounds, containing a double C=C bond. However, cycloalkanes are saturated compounds, with only single C-C bonds.
C They are saturated compounds – This is correct, as cycloalkanes are saturated compounds, with only single C-C bonds.
D They burn in excess oxygen to form CO_2 and H_2 – This is partially correct. The combustion of cycloalkanes and alkanes forms CO_2 and H_2O – **not** H_2.
E They are not members of a homologous series – This is incorrect. All alkenes, alkanes and cycloalkanes are members of a homologous series. This is as, they have almost same chemical properties due to presence of same functional group (CH_2). The physical properties (i.e. solubility, melting point, boiling point, state) of members of a **homologous series** either gradually increases or decrease with increase in molecular mass. This increase in molecular mass is uniform, often an increase in a multiple of CH_2.
F They are giant covalent compounds – This is incorrect, as they are simple molecular compounds. They are held together by strong covalent bonds, yet there exist weak intermolecular forces between the molecules.

2011 Q10 – the correct answer is D: The hydrocarbon, is essentially 2 cyclohexene molecules, with a loss of a C=C double bond, replace with a singular C-C single bond. Hence, the number of C atoms = 2 X C = 12; as each carbon joined to 2 other carbons – 12 – 2 = 10. Hence, 10 carbons.

First, each 10 carbons have 2 Hydrogen atoms each: 10 X 2 = 20. However, the carbons joined to 3 carbons only have 1 H atom each – which occurs twice in the structure. Hence, subtract 2 H atoms overall: 20 – 2 = 18

Mr = 10C + 18H $C_{10}H_{18}$ 10 (12) + 18(1) = 120 + 18 = 138

2010 Q10 – the correct answer is D: The only products of hydrocarbon fuel **complete** combustion are: CO_2 and H_2O.

C9 – Rates

2016 Q22 – the correct answer is B:
moles = concentration x volume x 10^{-3}
n (X): 100 x 1 x 10^{-3} = 0.1
mole ratio of 2HCl : CO_2 = 2:1
n(B): 50 x 2 x 10^{-3} = 0.1
The moles for both conditions are the same, hence indicating that the final volume of CO_2 produced is **constant** – the **same**. Hence, the line has to reach the same end point as X – it cannot be D, E or A. It's either C or B. However, the time taken to reach the end point of X (the rate of reaction) will differ. The concentration of HCl is higher in the second experiment, hence this **increases** the rate of reaction. This is as, a higher concentration of HCl molecules increase the likelihood of successful collisions with calcium carbonate chips, as they are more densely occupied in a small volume. Hence, it cannot be C, as the time taken is longer to reach the end point. Hence, it has to be B, as the time taken is smaller.

2014 Q6 – the correct answer is H: When the temperature of a reaction is **increased**, the particles **gain kinetic energy** so they move faster and increase the frequency of collisions. The proportion of successful collisions will also increase because the proportion of particles with energy greater than the activation energy has increased. This is why a small increase in temperature results in a large increase in the rate of a reaction. The activation energy is the minimum energy required by colliding particles to result in a successful collision and, therefore, a chemical change. Activation energy is a measure of the energy required to break chemical bonds and is not affected by temperature. Hence, an increase in temperature will have no effect on the activation energy but it will increase the frequency of collisions as well as the proportion of successful collisions.

2013 Q26 – the correct answer is B:

These are the correct equations:
3.) $NO + 1/2O_2 \rightarrow NO_2$
6.) $SO_2 + NO_2 \rightarrow SO_3 + NO$
This is as, the NO is equation 3, in the reactants, cancels with the NO equation 6 – as one of the products. Also, NO_2 as a product of equation 2, cancels with NO_2 in reaction 6, in the reactants. This cancelling means that, NO and NO_2 are catalysts, as they do not partake in the overall equation: $SO_2 + 1/2O_2 \rightarrow SO_3$. NO is regenerated in equation 6, and NO_2 is used up in equation 6.

2009 Q22 – the correct answer is D: Equation 2 is **very fast**, as it occurs between **oppositely charged ions**, which are attracted to each other due to electrostatic forces of attraction between them. $Ag^+ + Cl^-$ rapidly combine $\rightarrow$ AgCl.
Equation 3 is **very fast** as no bonds have to be broken. Also, the radicals combine rapidly, as they have a single **unpaired electron** in the outermost shell, as denoted by the dot. As both radicals have this, they combine to form a single C-C **covalent bond,** forming C_2H_6 (formed from $\cdot CH_3 + \cdot CH_3$).
Equations 1 and 2 are slow. Equation 1: H_2 needs to break up into 2 single H atoms, and I_2 needs to break up into 2 single I atoms. Then, 2HI molecules are formed separately. Hence, bonds are broken.
Equation 2: Firstly, there is no attraction to the negatively charged OH^- ion, as the CH_3Br is uncharged. Secondly, via electrophilic substitution, the OH^- needs to replace the $Br^=$, which involves bond breaking.

C10 – Balancing Equations

2014 Q2 – the correct answer is B: Reaction 1 is a redox reaction because there are changes in oxidation states (ionic charges): the oxidation state of copper changes from +2 to 0 ($Cu^{2+} + 2e– \rightarrow Cu$ [reduction]), and zinc changes from 0 to +2 ($Zn \rightarrow Zn^{2+} + 2e–$ [oxidation]). Reaction 2 is not a redox reaction because there is no electron transfer (no change in ionic charge, nor oxidation state). Reaction 3 is a redox reaction because there are changes in oxidation states (ionic charges): the oxidation state of magnesium changes from 0 to +2 ($Mg \rightarrow Mg^{2+} + 2e–$ [oxidation]), and hydrogen changes from +1 to 0 ($2H+ + 2e– \rightarrow H_2$ [reduction]). Reaction 4 is not a redox reaction because there is no transfer of electrons.

2014 Q10 – the correct answer is C: When balancing this chemical equation, you must have the same number of carbon atoms, hydrogen atoms and oxygen atoms on both the reactant side and the product side of the equation. This is only true for the correct answer, C. ‘a’ can be calculated first. With just one carbon on the right hand side of the equation it can be deduced that a=1. With this knowledge, the

remainder of the equation can be balanced and 'b' found. For instance, recognising 7 oxygen atoms are present on the left, and therefore 7 oxygen atoms much be present on the right, means that b must be 5.

2013 Q22 – the correct answer is C:

The half equation for $Cr_2O_7^{2-}$ $2Cr^{3+}$: (Firstly, $7H_2O$ is added on the LHS, as there are 7O on the RHS initially. $14H^+$ added on the RHS, as to balance 14H on LHS (as $7H_2$. Then, Cr_2 loses 6 electrons to form $2Cr^{3+}$; $Cr_2O_7^{2-}$ $2Cr^{3+} + 6e^-$)

$7H_2O + 2Cr^{3+}$ $Cr_2O_7^{2-} + 14H^+ + 6e^-$

Half Equation for C_2H_4O $C_2H_4O_2$: One oxygen atom is gained = oxidation = loss of electrons. 2 electrons are lost from the left hand side.

Hence, C_2H_4O $C_2H_4O_2 + 2e^-$

Balance with water on the LHS: $C_2H_4O + H_2O$ $C_2H_4O_2 + 2e^-$

Balance with H+ on RHS: $C_2H_4O + H_2O$ $C_2H_4O_2 + 2e^- + 2H^+$

Combining 2 half equations:

Equation 1: $Cr_2O_7^{2-} + 14H^+ + 6e^-$ $7H_2O + 2Cr^{3+}$

Equation 2: $C_2H_4O + H_2O$ $C_2H_4O_2 + 2e^- + 2H^+$ (multiply this equation by 3 to cancel electrons as they do not appear in final equation):

Equation 3: $3C_2H_4O + 3H_2O$ $3C_2H_4O_2 + 6e^- + 12H^+$

Combine Equation 1 and Equation 3: ($6e^-$ cancel out on both sides):

$Cr_2O_7^{2-} + 2H^+ + 3C_2H_4O$ $3C_2H_4O_2 + 4H_2O + 2Cr^{3+}$

Hence, $4H_2O$

2012 Q10 – the correct answer is D:

LHS: Na = 3, H = 3, P = 2, O = 8. RHS: Na = 5, P = 3, O = 11, H = 2

Firstly, considering Na: if b=2, Na is doubled on LHS giving $2Na_2HPO_4$ ->

LHS: Na = 5, H = 4, P = 3, O = 12 (Na is 5 on both sides)

Hence, as H = 4, let d = 2 on RHS: $2H_2O$ RHS: Na = 5, P= 3, O = 12, H =4

Both sides are balanced, hence a = 1, c=1.

$NaH_2PO_4 + 2Na_2HPO_4$ $Na_5P_3O_{10} + 2H_2O$

2011 Q18 – the correct answer is E:

Using simultaneous equations:

We can see that, a=x ; (H) b=2y ; (N) b=2x+2 ; (O) 3b=6x+y+2

Comparing b = 2y with b = 2x +2 $2x + 2 = 2y$ $x + 1 = y$

Substitute b=2y in O: $6y = 6x + y + 2$ $5y – 6x = 2$

Substitute $y = x + 1$ in $5y – 6x = 2$ $5(x+1) – 6x = 2$ $5x + 5 – 6x = 2$

hence x =3.

As $x + 1 = y$ $y = 4$

b=2y ; hence, b = 8

a=x hence, a = 3.

Hence, $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

2011 Q26 – the correct answer is E: From previously knowledge, sulphur impurities in petroleum fuel always release SO_2 to the atmosphere, when burnt. Hence, it can be D or E. The condition is, 'an excess of air', which indicates complete combustion. For complete combustion to occur, CO_2 must be a product, as opposed to CO. This eliminates D, hence E is the correct answer.

2010 Q14 – the correct answer is A:
1 Correct – $X^+ + e^- \rightarrow X$, as the X ion is electron deficient, and so the electron fills this vacancy to give atom X.
2 Correct – $X^- - e^- \rightarrow X$ has an excess of 1 electron, and so is negatively charged. Removing 1 electron will restore its neutrality, as an uncharged atom.
3 Incorrect – Adding 2 electrons to an already doubly charged negative ion, will increase the charge to 4-. Hence, the correct version: $O^{2+} + 2e^- \rightarrow O$.
4 Incorrect – Firstly, subtracting one electron off a doubly charged negative ion will give O^-. Secondly, O_2 molecule differs from the O atom, the molecule is formed by the covalent bond between 2 oxygen atoms. Here, one oxygen atom is doubly negatively charged, hence any modifications to it electronically, have to conserve the singularity of the species (only 1 O atom!). Correct version: $O^{2-} - e^- \rightarrow O^-$
5 Incorrect – 2I ions cannot give 1 I atom through electronic modifications, as the covalent bond needs to be broken. Hence, the correct versions: $I^- - 2e^- \rightarrow I^+$ / $2I^- - 2e^- \rightarrow 2I$
6 Correct – $Ca^{2+} + 2e^- \rightarrow Ca$. As, they are both oppositely charged ions, and the Ca^{2+} is doubly positively charged, hence requires 2 electrons to restore neutrality.

2009 Q14 – the correct answer is B: $MSO_4 + J \rightarrow JSO_4 + M$ – Reaction 2 would occur, as J is more reactive than M, and so it would displace it from MSO_4.
$TO + Q \rightarrow QO + T$ – Reaction 3 would occur, as Q is more reactive than T, and so it would displace it from TO.
$QO + J \rightarrow JO + Q$ – Reaction 4 would occur, as J is more reactive than Q, and so it would displace it from QO.

2009 Q18 – the correct answer is D:
LHS: Cu = 1, H = 1, N = 1, O = 3. RHS: Cu = 1, H = 2, O = 8, N = 4
Using algebra:
Cu (1 x a = 1 x a) ; H (1 x b = 2 x c) ; N (1 x b = 2 x a + 2) ;
O (3 x b = 6 x a +1 x c + 2)

Hence:

a=a
b=2c
b=2a+2
3b=6a + c + 2

We use substitution here:
6b=12a+2c+4
6b=12a+b+4
6(2a+2)=12a+(2a+2)+4
12a+12=12a+2a+2+4
12a+12=14a+6
2a=6
a=3
b=2a+2
b=6+2
b=8
b=2c
c=b/2
c=4
Hence, $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

C11 – Structure and Bonding

2014 Q22 – the correct answer is D: The graphene description indicates that it has a giant covalent structure. Typically, substances with a giant covalent structure have high melting and boiling points; they do not dissolve in water and they do not conduct electricity. However, the structure of graphene is very similar to that of graphite in that each C atom is covalently bonded to only 3 other C atoms which means that each C atom has a 'free' electron. This 'free' electron can migrate within the structure, so enabling graphene to conduct electricity. Graphene should have a high melting point and good electrical conductivity but not dissolve in water.

2012 Q18 – the correct answer is D: As vanadium lies above zinc, zinc lies directly above iron. Hence, iron cannot displace vanadium sulfate to obtain vanadium on its own.

2011 Q2 – the correct answer is B: X – in group 3 – has 3 electrons in its outermost shell. Y – in group 6 – has 6 electrons in its outermost shell. The metal X needs to remove all of its 3 electrons, and the non-metal Y needs to gain only 2 electrons. Hence, X can supply 2 electrons to each of the 3 Y atoms.

This is as, 3 X 2 = 6 (as the lowest common multiple between 2 and 3 is found). The supply of 6 electrons, due to 2 X atoms, balances with the demand of 6 electrons, due to 3 Y atoms. (2 x 3 = 6, 3 x 2 = 6)

2011 Q14 – the correct answer is C: Reading this question, you may be inclined to discard **all** ionic structures. However, the question asks for the compounds which **contain covalent bonds**. Hence, ionic compounds which involve a metal bonded to a **non metal compound** contains covalent bonds. This is as, the non metal compound itself, is formed from 2 or more non-metals, which are held together by covalent bonds.
Ionic compounds which have covalent bonds:a
$Ca(OH)_2$ covalent bond exists between O-H
$MgCO_3$ 3 covalent bonds between 3 C-O
Na_3PO_4 4 covalent bonds between 4 P-O
(This question is **not** to be confused with the property of covalent character – that property exists due to polarisation of electron density in ionic compounds due to the relative sizes and charges of the metal and non-metal ions. Ionic bonds with covalent character may or may not have covalent bonds.)

2009 Q6 – the correct answer is B: SiO_2 can exist as a giant structure – a covalent macromolecule, as it is held by strong covalent bonds. The strong covalent bonds link **all** the atoms together – a Si bonded to an O bonded to a Si bonded to an O etc.

C12 – Equilibria

2013 Q6 – the correct answer is B: The question asks for the greatest product.
Temperature: The forward reaction is **exothermic**, due to **negative enthalpy change**. Hence, the forward reaction releases energy. **Decreasing** temperature favours the forward reaction, as more heat can be produced, hence the equilibrium shifts to the right, giving more product T. This is as, equilibrium shifts to oppose the decrease in temperature, by releasing more heat. Increasing the temperature would favour the reverse reaction, which is endothermic, as the heat can be absorbed to break bonds and produce more reactants.
Pressure: A high pressure favours the forward reaction, as the RHS contains fewer moles (2 moles), compared to the LHS (3 moles). The equilibrium shifts to oppose the increase in pressure, by giving product which has fewer moles. A decrease in pressure would favour the reverse reaction, as the LHS contains a higher moles than RHS.

R and S: Adding R would favour the forward reaction, as the equilibrium shifts to the right to oppose the increase in R, by producing more product. The same reason applies for S, as it is a reactant.

Catalyst: A catalyst has no effect on the attainment of equilibrium, but only affects (which is always to increase) the rate of attainment of equilibrium. Hence, the neither the presence nor absence of product T would affect the production of R. In this case, the option is ‘absent’, which is correct due to the above reason.