Algebra II

The correct order to perform a series of operations: BODMAS

3

Answers to additional problems

3.1 $$\underbrace{2\,\text{mol}\times 98\,\text{g mol}^{-1}}_{\text{sulphuric acid}}+\underbrace{12\,\text{mol}\times 18\,\text{g mol}^{-1}}_{\text{water}}$$

There are two operators, both MULTIPLICATION and ADDITION. MULTIPLICATION has the higher priority, so the correct order in which to perform the calculation is:

Notice how the units of mol and mol^{-1} cancel here.

1. MULTIPLY 2 mol by 98 g mol^{-1} and 12 mol by 18 g mol^{-1}.
2. ADD together these two numbers

The mass is therefore:

1. 196 g + 216 g
2. 412 g

3.2 Molar mass $M = m(\text{Fe}) \times 1 + m(\text{NO}_3) \times 3 + m(\text{H}_2\text{O}) \times 9$

There are two operators, both MULTIPLICATION and ADDITION. MULTIPLICATION has the higher priority so the correct order in which to perform the calculation is,

The symbol m here denotes mass and M denotes molar mass.

1. MULTIPLY $m(\text{Fe})$ by 1, $m(\text{NO}_3)$ by 3, and $m(\text{H}_2\text{O})$ by 9.
2. ADD together these three numbers.

The mass of a mole of iron is 56 g, a mole of nitrate ion has a mass of (14 + 3 × 16) = 62 g and a mole of water has a mass of (2 × 1 + 16) = 18 g.

1. The three terms are 56 g × 1 = 56 g, 62 g × 3 = 186 g, and 18 g × 9 = 162 g.
2. The sum of these numbers is (56 + 186 + 162) g = 404 g. The molar mass $M = 404\ \text{g mol}^{-1}$.

3.3 $$\underbrace{12\times 500\text{g}}_{\text{A}}+\underbrace{7\times 250\text{g}}_{\text{B}}$$

There are two operators, both MULTIPLICATION and ADDITION. MULTIPLICATION has the higher priority so the correct order in which to perform the calculation is,

1. MULTIPLY 500 g by 12 and 250g by 7.
2. ADD together these two numbers.
3. 500 g ×12 = 6000 g and 250g × 7 = 1750 g.
4. 6000 g + 1750 g = 7750 g.

3.4 The equation contains two operators: SUBTRACTION and DIVISION. But examples of this type imply the top line of the fraction (the numerator) should be treated as a BRACKET,

$$a=\frac{(v-u)}{t}$$

The BRACKET takes priority. The correct order is therefore,

1. Perform the calculation within the BRACKET
2. We perform the DIVISION

1. The SUBTRACTION within the numerator BRACKET is (650 – 30) m s^{-1} = 620 m s^{-1}
2. The DIVISION of the fraction is $\frac{620\text{m s}^{-1}}{3.9\text{ s}}$ = 159 m s^{-2}.

3.5 There are two explicit functions here, both SUBTRACTION and DIVISION. The DIVISION has the higher priority. As in the previous example, the terms within the numerator and within the denominator are best regarded as residing within BRACKETS,

$$\text{gradient} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

The bracket takes priority. The correct order is therefore,

1. Perform the calculations within the BRACKETS.
2. Perform the DIVISION.

1. The denominator is (5.5 – 4.1) = 1.4 and the numerator is (12 –3.0) = 9.0
2. The DIVISION yields, $\frac{9.0}{1.4} = 6.4$

3.6 We have MULTIPLIED together the three terms n, F, and the bracket. The BRACKET term is itself an operator because it contains both SUBTRACTION and a DIVISION operations.

In common with Additional Problems 3.4 and 3.5, the DIVISION problem in the BRACKET needs to be considered as having a bracketed numerator and denominator,

$$\Delta S_{(\text{cell})} = nF\left(\frac{E_{(\text{cell})2} - E_{(\text{cell})1}}{T_2 - T_1}\right)$$

The correct order in which to perform the calculation is,

1. The BRACKETS which comprise the numerator and the denominator (both of which are subtraction operations).
2. The DIVISION within the overall, larger bracket.
3. The MULTIPLICATION of n, F, and the larger bracket.

1. The numerator is (1.436 – 1.440) V = –0.004 V and the denominator is (330 – 298) K = 32 K.
2. The DIVISION operation in the larger bracket, $\frac{-0.004\text{V}}{32\text{K}}$ = –1.25 × 10^{-4} V K^{-1}.
3. The MULTIPLICATION operation is $n \times F \times$ (bracket) so 2 × 96 485 C mol^{-1} × –1.25 × 10^{-4} V K^{-1} = –24.1 C V K^{-1} mol^{-1}.

The compound unit of (C V) simplifies to J making the final answer, $\Delta S_{(\text{cell})}$ = –24.1 J K^{-1} mol^{-1}.

3.7

$$\text{mark} = \underbrace{20\text{Cr} \times 70\%}_{\text{physical}} + \underbrace{20\text{Cr} \times 63\%}_{\text{inorganic}} + \underbrace{20\text{Cr} \times 59\%}_{\text{organic}} + \underbrace{40\text{Cr} \times 50\%}_{\text{analytical}}$$

where Cr means 'credits'.

There are two operators here: MULTIPLICATION and ADDITION. Multiplication has the higher priority, so the correct order in which to perform the calculation is,

1. MULTIPLY 20 by 70%; 20 by 63%; 20 by 59%; and 40 by 50%.
2. ADD together these four numbers

1. 20 × 0.70 = 14; 20 × 0.63 = 12.6; 20 × 0.59 = 11.8; and 40 × 0.50 = 20
2. Final mark = 14 + 12.6 + 11.8 + 20 = 58.4%

3.8 There are four operators: MULTIPLICATION, ADDITION, and a BRACKET (in which a SUBTRACTION operation occurs). We first perform the SUBTRACTION operation within the BRACKET. The correct order in which to perform the calculation is,

1. The SUBTRACTION operation within the BRACKET
2. MULTIPLY the result of the bracket with C_p to yield $C_p(T_2 - T_1)$

3. Remember to convert ΔH_1 to SI units of J mol^{-1} by multiplying by 1000.
4. ADD together ΔH_1 and $C_p(T_2 - T_1)$

1. (330 – 298) K = 32 K
2. $C_p(T_2 - T_1)$ = 31.2 J K^{-1} mol^{-1} × 32 K = 998.4 J mol^{-1}
3. ΔH_2 = 12 000 J mol^{-1} + 998.4 J mol^{-1} = 12 998 J mol^{-1}. This enthalpy is 13 000 J mol^{-1} to 2 s.f. It's best to then cite this value with a standard factor as 13 kJ mol^{-1}.

kJ means 1000 × J. Accordingly, 12 998 J mol^{-1} could be written as 13 kJ mol^{-1}.

3.9 The square on the *c* term is treated as a function OF *c*, so the square has priority. The correct order in which to perform the calculation is,

1. SQUARE the *c* term.
2. MULTIPLY c^2 by *m*.

Therefore, $E = 0.11 \text{ kg} \times (3 \times 10^8 \text{ m s}^{-1})^2$.

$$E = 0.11 \text{ kg} \times (9 \times 10^{16} \text{ m}^2 \text{ s}^{-2}).$$

$$E = 9.9 \times 10^{15} \text{ J}.$$

These units of 'kg m^2 s^{-2}' coalesce to form Joules J.

3.10 We regard the square on *T* as a function OF *T*. Accordingly, there are three operators of MULTIPLICATION, SUBTRACTION, and OF. The correct order in which to perform the calculation is

1. SQUARE We SQUARE *T* to form T^2.
2. MULTIPLY 4.99 × 10^{-6} by *T*, and 3.45 × 10^{-8} by T^2
3. SUBTRACT 4.99 × 10^{-6} × *T* and 3.45 × 10^{-8} × T^2 from 0.07131 V

1. $T^2 = (312 \text{ K})^2 = 97\,344 \text{ K}^2$.
2. 4.99 × 10^{-6} × *T* = 0.001 56 V, and 3.45 × 10^{-8} × T^2 = 0.003 36 V.
3. $E_{\text{AgBr,Ag}}$ = 0.071 31 – 0.001 56 – 0.003 36 V = 0.066 4 V. (to 3 s.f.)