0.1 Basic chemistry competencies

0.1.1. Balancing equations

Accept multiples or appropriate fractions, 1 mark each.

1. \(2C + \ldots\cdot O_2 \rightarrow 2CO\)

2. \(\ldots\cdot 2Ba + \ldots\cdot 2H_2O \rightarrow 2Ba(OH)_2 + \ldots\cdot H_2\)

3. \(\ldots\cdot C_2H_6 + 3\ldots\cdot O_2 \rightarrow 2CO_2 + 3H_2O\)

4. \(\ldots\cdot 2HCl + \ldots\cdot Mg(OH)_2 \rightarrow \ldots\cdot MgCl_2 + 2H_2O\)

5. \(\ldots\cdot N_2 + \ldots\cdot O_2 \rightarrow 2NO\)

6. \(\ldots\cdot 2Fe_3O_3 + \ldots\cdot 3C \rightarrow 4Fe + 3CO_2\)

7. \(\ldots\cdot CH_3CH_2OH + 2[O] \rightarrow \ldots\cdot CH_3COOH + \ldots\cdot H_2O\)

8. \(\ldots\cdot 2HNO_3 + \ldots\cdot CuO \rightarrow \ldots\cdot Cu(NO_3)_2 + H_2O\)

9. \(\ldots\cdot Al^{3+} + 3e^- \rightarrow \ldots\cdot Al\)

10. \(\ldots\cdot 2Fe(H_2O)_6^{3+} + 3CO_3^{2-} \rightarrow 2Fe(OH)_3(H_2O)_3 + 3CO_2 + 3H_2O\)

0.1.2. Constructing ionic formulae

1.

a. \(Mg^{2+} O^{2-} = MgO\) (1 mark)

b. \(Na^{+} SO_4^{2-} = Na_2SO_4\) (1 mark)

c. \(Ca^{2+} OH^- = Ca(OH)_2\) (1 mark)

d. \(Al^{3+} O^{2-} = Al_2O_3\) (1 mark)

e. \(Cu^{+} O^{2-} = Cu_2O\) (1 mark)
2.

a. $\text{SO}_4^{2-}$  
(1 mark)
b. $\text{NO}_3^-$  
(1 mark)
c. $\text{PO}_4^{3-}$  
(1 mark)
d. $\text{HCOO}^-$  
(1 mark)
e. $\text{CO}_3^{2-}$  
(1 mark)

0.1.3. Writing equations from text

1 mark each, accept multiples for all except question 9.

1. $3\text{Si} + 2\text{N}_2 \rightarrow \text{Si}_3\text{N}_4$
2. $\text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$
3. $\text{B} + 1.5\text{Cl}_2 \rightarrow \text{BCl}_3$
4. $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$
5. $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$
6. $\text{SiO}_2 + \text{C} + 2\text{Cl}_2 \rightarrow \text{SiCl}_4 + \text{CO}_2$
7. $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
8. $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
9. $0.5\text{Cl}_2 + 1.5\text{F}_2 \rightarrow \text{ClF}_3$
10. $2\text{NO}_2 + \text{H}_2\text{O} + 0.5\text{O}_2 \rightarrow 2\text{HNO}_3$
0.2 Basic mathematical competencies

0.2.1. Rearranging equations

1.
   a. \[ c = \frac{1000n}{v} \] \hspace{1cm} (1 mark)
   b. \[ v = \frac{1000n}{c} \] \hspace{1cm} (1 mark)

2.
   a. \[ m = d \times v \] \hspace{1cm} (1 mark)
   b. \[ d = \frac{m \times 10^{-3}}{v \times 10^{-6}} = \frac{m}{v \times 10^{-3}} \]
      1 mark for both parts of the fraction correct, 1 mark for cancelling down the \( \times 10^{-6} \) to \( \times 10^{-3} \). \hspace{1cm} (2 marks)

3.
   a. \[ p = \frac{h}{\lambda} \] \hspace{1cm} (1 mark)
   b. \[ v = \frac{h}{\lambda m} \] \hspace{1cm} (1 mark)
      1 mark for substitution of \( p = mv \) into the first equation and 1 mark for successful rearrangement. \hspace{1cm} (2 marks)

4.
   \[ v = \sqrt{\frac{KE}{0.5m}} \text{ or } v = \sqrt{\frac{2KE}{m}} \]
      1 mark for first rearrangement moving 0.5 m underneath the KE, 1 mark for dealing with the \( v^2 \) by addition of the square root. \hspace{1cm} (2 marks)

0.2.2. BODMAS

1. a. 28
   b. 40
   c. 8
   d. 45
   e. 6
   f. 40
2.  
   a. 180  \hspace{1cm} (1 \text{ mark})
   b. 5352  \hspace{1cm} (1 \text{ mark})
   c. 180  \hspace{1cm} (1 \text{ mark})

Evaluation: Pressing equals after each operation leads to BODMAS errors.  \hspace{1cm} (1 \text{ mark})

0.2.3. Quantity calculus

1. g cm\(^{-3}\)  \hspace{1cm} (1 \text{ mark})
2. mol dm\(^{-3}\)  \hspace{1cm} (1 \text{ mark})
3. g cm\(^{-3}\)  \hspace{1cm} (1 \text{ mark})
4. mol dm\(^{-3}\) s\(^{-1}\)  \hspace{1cm} (1 \text{ mark})
5. N m\(^{-2}\)  \hspace{1cm} (1 \text{ mark})

6.  
   a. mol\(^2\) dm\(^{-6}\)  \hspace{1cm} (1 \text{ mark})
   b. mol\(^{-1}\) dm\(^{3}\) s\(^{-1}\)  \hspace{1cm} (1 \text{ mark})
   c. kPa\(^{-0.5}\)  \hspace{1cm} (1 \text{ mark})
   d. mol\(^2\) dm\(^{-6}\)  \hspace{1cm} (1 \text{ mark})
   e. mol dm\(^{-3}\)  \hspace{1cm} (1 \text{ mark})
0.2.4. Expressing large and small numbers

1. a. \(1.06 \times 10^6\)  
   b. \(1.06 \times 10^{-3}\)  
   c. \(2.222 \times 10^2\)

   (1 mark)
   (1 mark)
   (1 mark)

2. 1 mark for sensible choice of \(\times 10^x\) power, in this case \(\times 10^{-2}\) or \(\times 10^{-3}\) is most sensible. 0.5 marks for each number correctly converted.

3. a. \(10^4\)  
   b. \(10^{14}\)  
   c. \(0.5 \times 10^{-11}\) or \(5 \times 10^{-12}\)  
   d. \(2.4 \times 10^2\)

   (1 mark)
   (1 mark)
   (1 mark)

0.2.5. Significant figures, decimal places and rounding

<table>
<thead>
<tr>
<th></th>
<th>Significant figures</th>
<th>Decimal places</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.131 88</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>1000</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0.000 65</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1006</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>560.0</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>0.000 480</td>
<td>3</td>
</tr>
</tbody>
</table>

(0.5 mark for each correct answer)

7. a. i. 0.0758  
   ii. 0.08

   (1 mark)
   (1 mark)

b. i. 231
   ii. 231.46

   (1 mark)
   (1 mark)
0.2.6. Unit conversions 1 – Length, mass and time

1. 12 mm (1 mark)
2. 72.00 m (1 mark)
3. 270 s (1 mark)
4. 154 s (1 mark)
5. 2 h 25 min (1 mark)
6. 15.5 t (1 mark)
7. 26.5 g (1 mark)
8. 75 mg/tablet = 0.075 g/tablet
   1 g ÷ 0.075 g/tablet = 13.3 tablets
   Minimum number of tablets needed = 14 (1 mark)
9. 30 g/min (1 mark)
   NOTE In this example, as you are converting 1/the unit, you need to do the inverse of what is described in the diagram eg instead of ÷ 60, × 60.
10. 10.44 kg/h = 10 440 g/h = 174 g/min = 2.9 g/s (1 mark)

0.2.7. Unit conversions 2 – Volume

1. drinks bottle, 1 dm³; sugar cube, 1 cm³; washing machine, 1 m³ (1 mark)
2. To convert a volume in cm³ into a volume in dm³, divide by 1000. (½ mark)
   To convert a volume in cm³ into a volume in m³, divide by 1 000 000. (½ mark)
3. a. 1.6 dm³ (1 mark)
b. 5.5 × 10⁻⁴ m³ (1 mark)
c. 1350 cm³ (1 mark)
d. 375 000 000 cm³ (1 mark)
e. 0.006 54 m³ (1 mark)
4. |     | £ per m³ | p per cm³ | p per dm³ |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder ‘a’</td>
<td>7.27</td>
<td>7.27 × 10⁻⁴</td>
<td>0.727</td>
</tr>
<tr>
<td>Cylinder ‘b’</td>
<td>7.87</td>
<td>7.87 × 10⁻⁴</td>
<td>0.787</td>
</tr>
<tr>
<td>Cylinder ‘c’</td>
<td>4.11</td>
<td>4.11 × 10⁻⁴</td>
<td>0.411</td>
</tr>
</tbody>
</table>

Therefore ‘c’ is the best value for money.
0.2.8. Moles and mass

1. a. 32.0 g ÷ 16.0 g mol⁻¹ = 2 mol (1 mark)
b. 175 g ÷ 100.1 g mol⁻¹ = 1.75 mol (1 mark)
c. 0.2 g ÷ 180.0 g mol⁻¹ = 0.0011 mol (1 mark)

2. a. 20 mol × 180 g mol⁻¹ = 3 600 g (1 mark)
b. 5.00 × 10⁻³ mol × 63.5 g mol⁻¹ = 0.318 g (1 mark)
c. 42.0 mol × 249.6 g mol⁻¹ = 10 500 g (1 mark)

3. a. i. 3.09 g ÷ 0.0250 mol = 123.6 g mol⁻¹ (1 mark)
    ii. CuCO₃ (1 mark)
    b. molar mass of chromium carbonate = 4.26 g ÷ 0.015 mol = 284 g mol⁻¹ (1 mark)
    Cr₂(CO₃) (1 mark)

BONUS QUESTION
6.02 × 10²³ p ÷ 7 500 000 000 people = 8.03 × 10¹³ p per person or 803 000 million pounds per person!

0.2.9. Moles and concentration

1. a. 1.5 mol ÷ 0.25 dm³ = 6.0 mol dm⁻³ (1 mark)
b. 0.25 dm³ × 0.0150 mol dm⁻³ = 3.75 × 10⁻³ mol (1 mark)
c. 0.125 mol ÷ 0.85 mol dm⁻³ = 0.15 dm³ (1 mark)

2. a. 5.0 g ÷ 84.0 g mol⁻¹ = 0.0595 mol (1 mark)
    0.0595 mol ÷ 0.100 dm³ = 0.60 mol dm⁻³ (1 mark)
b. 0.025 dm³ × 3.8 mol dm⁻³ = 0.095 mol (1 mark)
    0.095 mol × 40.0 g mol⁻¹ = 3.8 g (1 mark)
c. 2.5 g ÷ 129.9 g mol⁻¹ = 0.0192 mol (1 mark)
    0.0192 mol ÷ 1.3 mol dm⁻³ = 0.015 dm³ (1 mark)
    0.0148 dm³ = 15 cm³ (to 2 sig. fig.) (1 mark)
0.3 Basic practical competencies

0.3.1. Laboratory equipment

1. For each part (a)–(e) give ½ mark for the correct name and ½ mark for one or more correct possible volumes depending on what is available in your laboratory.

   a. conical flask
      100 cm³ / 250 cm³
   b. beaker
      100 cm³ / 250 cm³
   c. volumetric flask
      100 cm³ / 200 cm³ / 250 cm³
   d. test tube or boiling tube
      10 cm³ or 25 cm³
   e. burette
      50 cm³
   f. pipette
      various sizes although 20 cm³ or 25 cm³ are the most common at school level

2. a. (gas) syringe (1 mark)
   b. evaporating basin (1 mark)
   c. crucible (1 mark)
   d. pestle and mortar (the mortar is the bowl) (1 mark)

0.3.2. Recording results

1. Improvements: (1 mark for each improvement identified)
   • Units for temperature should be included in the table headings.
   • All results should be recorded to the same number of decimal places (the resolution of the thermometer used), in this case 1 d.p.
   • The temperature changes are negative and so should be recorded as such, eg –22.1, or the heading should be changed to ‘Temperature decrease’ or similar.
   • The temperature change for Run 3 is anomalous and so should be circled, or similar, to show this. It is correctly not included in the calculation of the mean.
   • The mean temperature change should be stated to the same number of significant figures as the values from which it is calculated.
0. TRANSITION SKILLS Answers

2. Experiment 1: (2 marks)

<table>
<thead>
<tr>
<th></th>
<th>Mass / g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crucible empty</td>
<td></td>
</tr>
<tr>
<td>Crucible + magnesium</td>
<td></td>
</tr>
<tr>
<td>Crucible + magnesium</td>
<td></td>
</tr>
</tbody>
</table>

1 mark – Units given in table heading
1 mark – Clear description of item of which the mass is being recorded
Use teacher discretion to award marks for other suitable tables

Experiment 2: (3 marks)

<table>
<thead>
<tr>
<th>Time / s</th>
<th>Volume of hydrogen gas produced / cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5 mol dm⁻³ HCl(aq)</td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>160</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td></td>
</tr>
</tbody>
</table>

1 mark – Columns clearly labelled with units
1 mark – Dependent variable (volume of hydrogen gas) across columns
Independent variable (time) down rows
1 mark – Time starts at 0 and is in seconds throughout table (ie not 1 min 20 s)
0.3.3. Drawing scatter graphs

1. Graph plotted with marks allocated as follows:
   - Temperature on the x-axis, volume on the y-axis. \( (1 \text{ mark}) \)
   - Suitable scales are chosen so that the plotted points cover more than half the graph paper (ie axes do not start at 0). \( (1 \text{ mark}) \)
   - Axes labelled with value and unit. \( (1 \text{ mark}) \)
   - Points are plotted accurately with a neat pencil cross and within ±1 square.
     - All points plotted accurately 3 marks
     - 4 points plotted accurately 2 marks
     - 3 points plotted accurately 1 mark
     - 2 points plotted accurately 0 marks

2. Error bars are added to each plotted point (except 80 °C, 51.0 cm\(^3\)) \( (1 \text{ mark}) \)
   Anomalous values circled in table not included in error bars \( (1 \text{ mark}) \)

3. Suitable line of best fit drawn \( (1 \text{ mark}) \)

4. As the temperature increases the volume of the gas increases (or suitable similar comparative statement) \( (1 \text{ mark}) \)