

# CHEMISTRY

## Written examination 2

### DATA SHEET

#### Directions to students

This data sheet is provided as a reference.

Make sure that you remove this data sheet from the question and answer book during reading time.

Any writings, jottings, notes or drawings made on this data sheet will **not** be considered in the marking.

At the end of the examination, ensure that you do **not** leave the data sheet in the question and answer book.

You may keep this data sheet.

**Physical constants**

$$F = 96\,500 \text{ C mol}^{-1}$$

$$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mmHg}$$

$$0^\circ\text{C} = 273 \text{ K}$$

$$\text{Molar volume at STP} = 22.4 \text{ L mol}^{-1}$$

$$\text{Avogadro constant} = 6.02 \times 10^{23} \text{ mol}^{-1}$$

**Ideal gas equation**

$$pV = nRT$$

**The electrochemical series**

|                                                                                                                    | $E^\circ$ in volts |
|--------------------------------------------------------------------------------------------------------------------|--------------------|
| $\text{F}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{F}^-(\text{aq})$                                            | +2.87              |
| $\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$ | +1.77              |
| $\text{Au}^+(\text{aq}) + \text{e}^- \rightarrow \text{Au}(\text{s})$                                              | +1.68              |
| $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$                                          | +1.36              |
| $\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$            | +1.23              |
| $\text{Br}_2(\text{l}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$                                          | +1.09              |
| $\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$                                              | +0.80              |
| $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$                                     | +0.77              |
| $\text{I}_2(\text{s}) + 2\text{e}^- \rightarrow 2\text{I}^-(\text{aq})$                                            | +0.54              |
| $\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$           | +0.40              |
| $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$                                          | +0.34              |
| $\text{S}(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2\text{S}(\text{g})$               | +0.14              |
| $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$                                            | 0.00               |
| $\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$                                          | -0.13              |
| $\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$                                          | -0.14              |
| $\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$                                          | -0.23              |
| $\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Co}(\text{s})$                                          | -0.28              |
| $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$                                          | -0.44              |
| $\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$                                          | -0.76              |
| $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$           | -0.83              |
| $\text{Mn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mn}(\text{s})$                                          | -1.03              |
| $\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$                                          | -1.67              |
| $\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$                                          | -2.34              |
| $\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$                                              | -2.71              |
| $\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ca}(\text{s})$                                          | -2.87              |
| $\text{K}^+(\text{aq}) + \text{e}^- \rightarrow \text{K}(\text{s})$                                                | -2.93              |
| $\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$                                              | -3.02              |

# Periodic table of the elements

|                                 |                                 |                                 |                                  |                                  |                                  |                                  |                                  |                                  |                                   |                                   |                                   |                                 |                                   |                                 |                                   |                                 |                                   |
|---------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------------------|-----------------------------------|---------------------------------|-----------------------------------|---------------------------------|-----------------------------------|
| <b>1</b><br><b>H</b><br>1.0     |                                 |                                 |                                  |                                  |                                  |                                  |                                  |                                  |                                   |                                   |                                   |                                 |                                   |                                 |                                   |                                 | <b>2</b><br><b>He</b><br>4.0      |
| <b>3</b><br><b>Li</b><br>6.9    | <b>4</b><br><b>Be</b><br>9.0    |                                 |                                  |                                  |                                  |                                  |                                  |                                  |                                   |                                   |                                   |                                 |                                   |                                 |                                   | <b>9</b><br><b>F</b><br>19.0    | <b>10</b><br><b>Ne</b><br>20.1    |
| <b>11</b><br><b>Na</b><br>23.0  | <b>12</b><br><b>Mg</b><br>24.3  |                                 |                                  |                                  |                                  |                                  |                                  |                                  |                                   |                                   |                                   |                                 |                                   |                                 |                                   | <b>17</b><br><b>Cl</b><br>35.5  | <b>18</b><br><b>Ar</b><br>39.9    |
| <b>19</b><br><b>K</b><br>39.1   | <b>20</b><br><b>Ca</b><br>40.1  | <b>21</b><br><b>Sc</b><br>44.9  | <b>22</b><br><b>Ti</b><br>47.9   | <b>23</b><br><b>V</b><br>50.9    | <b>24</b><br><b>Cr</b><br>52.0   | <b>25</b><br><b>Mn</b><br>54.9   | <b>26</b><br><b>Fe</b><br>55.9   | <b>27</b><br><b>Co</b><br>58.9   | <b>28</b><br><b>Ni</b><br>58.7    | <b>29</b><br><b>Cu</b><br>63.6    | <b>30</b><br><b>Zn</b><br>65.4    | <b>31</b><br><b>Ga</b><br>69.7  | <b>32</b><br><b>Ge</b><br>72.6    | <b>33</b><br><b>As</b><br>74.9  | <b>34</b><br><b>Se</b><br>79.0    | <b>35</b><br><b>Br</b><br>79.9  | <b>36</b><br><b>Kr</b><br>83.8    |
| <b>37</b><br><b>Rb</b><br>85.5  | <b>38</b><br><b>Sr</b><br>87.6  | <b>39</b><br><b>Y</b><br>88.9   | <b>40</b><br><b>Zr</b><br>91.2   | <b>41</b><br><b>Nb</b><br>92.9   | <b>42</b><br><b>Mo</b><br>95.9   | <b>43</b><br><b>Tc</b><br>98.1   | <b>44</b><br><b>Ru</b><br>101.1  | <b>45</b><br><b>Rh</b><br>102.9  | <b>46</b><br><b>Pd</b><br>106.4   | <b>47</b><br><b>Ag</b><br>107.9   | <b>48</b><br><b>Cd</b><br>112.4   | <b>49</b><br><b>In</b><br>114.8 | <b>50</b><br><b>Sn</b><br>118.7   | <b>51</b><br><b>Sb</b><br>121.8 | <b>52</b><br><b>Te</b><br>127.6   | <b>53</b><br><b>I</b><br>126.9  | <b>54</b><br><b>Xe</b><br>131.3   |
| <b>55</b><br><b>Cs</b><br>132.9 | <b>56</b><br><b>Ba</b><br>137.3 | <b>57</b><br><b>La</b><br>138.9 | <b>72</b><br><b>Hf</b><br>178.5  | <b>73</b><br><b>Ta</b><br>180.9  | <b>74</b><br><b>W</b><br>183.8   | <b>75</b><br><b>Re</b><br>186.2  | <b>76</b><br><b>Os</b><br>190.2  | <b>77</b><br><b>Ir</b><br>192.2  | <b>78</b><br><b>Pt</b><br>197.0   | <b>79</b><br><b>Au</b><br>197.0   | <b>80</b><br><b>Hg</b><br>200.6   | <b>81</b><br><b>Tl</b><br>204.4 | <b>82</b><br><b>Pb</b><br>207.2   | <b>83</b><br><b>Bi</b><br>209.0 | <b>84</b><br><b>Po</b><br>(209)   | <b>85</b><br><b>At</b><br>(210) | <b>86</b><br><b>Rn</b><br>(222)   |
| <b>87</b><br><b>Fr</b><br>(223) | <b>88</b><br><b>Ra</b><br>(226) | <b>89</b><br><b>Ac</b><br>(227) | <b>104</b><br><b>Rf</b><br>(261) | <b>105</b><br><b>Db</b><br>(262) | <b>106</b><br><b>Sg</b><br>(263) | <b>107</b><br><b>Bh</b><br>(264) | <b>108</b><br><b>Hs</b><br>(265) | <b>109</b><br><b>Mt</b><br>(268) | <b>110</b><br><b>Uun</b><br>(269) | <b>111</b><br><b>Uuu</b><br>(271) | <b>112</b><br><b>Uub</b><br>(272) |                                 | <b>114</b><br><b>Uuq</b><br>(274) |                                 | <b>116</b><br><b>Uuh</b><br>(276) |                                 | <b>118</b><br><b>Uuo</b><br>(278) |

|                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                 |
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| <b>58</b><br><b>Ce</b><br>140.1 | <b>59</b><br><b>Pr</b><br>140.9 | <b>60</b><br><b>Nd</b><br>144.2 | <b>61</b><br><b>Pm</b><br>(145) | <b>62</b><br><b>Sm</b><br>150.3 | <b>63</b><br><b>Eu</b><br>152.0 | <b>64</b><br><b>Gd</b><br>157.2 | <b>65</b><br><b>Tb</b><br>158.9 | <b>66</b><br><b>Dy</b><br>162.5 | <b>67</b><br><b>Ho</b><br>164.9 | <b>68</b><br><b>Er</b><br>167.3 | <b>69</b><br><b>Tm</b><br>168.9 | <b>70</b><br><b>Yb</b><br>173.0 | <b>71</b><br><b>Lu</b><br>175.0 |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|

|                                 |                                 |                                |                                 |                                 |                                 |                                 |                                 |                                 |                                 |                                  |                                  |                                  |                                  |
|---------------------------------|---------------------------------|--------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| <b>90</b><br><b>Th</b><br>232.0 | <b>91</b><br><b>Pa</b><br>231.0 | <b>92</b><br><b>U</b><br>238.0 | <b>93</b><br><b>Np</b><br>237.1 | <b>94</b><br><b>Pu</b><br>(244) | <b>95</b><br><b>Am</b><br>(243) | <b>96</b><br><b>Cm</b><br>(247) | <b>97</b><br><b>Bk</b><br>(247) | <b>98</b><br><b>Cf</b><br>(251) | <b>99</b><br><b>Es</b><br>(254) | <b>100</b><br><b>Fm</b><br>(257) | <b>101</b><br><b>Md</b><br>(258) | <b>102</b><br><b>No</b><br>(259) | <b>103</b><br><b>Lr</b><br>(260) |
|---------------------------------|---------------------------------|--------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|

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