



## **CHEMISTRY**

### **Practice written examination**

#### **DATA BOOK AND ANSWER SHEET**

##### **Instructions**

This data book is provided for your reference.

A question and answer book is provided with this data book.

##### **At the end of the examination**

Place the answer sheet for multiple-choice questions inside the front cover of your question book.

You may keep the data book.

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## 1. Periodic table of the elements

<b>1</b>	<b>H</b>	hydrogen	<b>2</b>	<b>He</b>	helium
<b>3</b>	<b>Li</b>	lithium	<b>4</b>	<b>Be</b>	beryllium
<b>11</b>	<b>Na</b>	sodium	<b>12</b>	<b>Mg</b>	magnesium
<b>19</b>	<b>K</b>	potassium	<b>20</b>	<b>Ca</b>	calcium
<b>37</b>	<b>Rb</b>	rubidium	<b>38</b>	<b>Sr</b>	strontium
<b>55</b>	<b>Ba</b>	barium	<b>56</b>	<b>Cs</b>	caesium
<b>87</b>	<b>Fr</b>	francium	<b>88</b>	<b>Ra</b>	radium
atomic number					
<b>79</b>					
symbol of element					
<b>Au</b>					
relative atomic mass					
197.0					
gold					
<b>5</b>	<b>B</b>	boron	<b>6</b>	<b>C</b>	carbon
<b>13</b>	<b>Al</b>	aluminium	<b>14</b>	<b>Si</b>	silicon
<b>19</b>	<b>P</b>	phosphorus	<b>15</b>	<b>S</b>	sulfur
<b>31</b>	<b>Zn</b>	zinc	<b>16</b>	<b>Cl</b>	chlorine
<b>32</b>	<b>Ga</b>	gallium	<b>17</b>	<b>F</b>	fluorine
<b>33</b>	<b>Ge</b>	germanium	<b>18</b>	<b>Ar</b>	argon
<b>34</b>	<b>As</b>	arsenic	<b>19</b>	<b>Ne</b>	neon
<b>35</b>	<b>Se</b>	selenium	<b>20</b>	<b>Kr</b>	krypton
<b>36</b>	<b>Br</b>	bromine	<b>21</b>	<b>Xe</b>	xenon
<b>37</b>	<b>In</b>	antimony	<b>22</b>	<b>Tl</b>	astatine
<b>38</b>	<b>Rh</b>	rhodium	<b>23</b>	<b>Te</b>	radon
<b>39</b>	<b>Pd</b>	palladium	<b>24</b>	<b>Po</b>	oganesson
<b>40</b>	<b>Ag</b>	silver	<b>25</b>	<b>At</b>	(294)
<b>41</b>	<b>Os</b>	osmium	<b>26</b>	<b>Bi</b>	(222)
<b>42</b>	<b>Ru</b>	rhodium	<b>27</b>	<b>Pb</b>	(210)
<b>43</b>	<b>Tc</b>	technetium	<b>28</b>	<b>Po</b>	(210)
<b>44</b>	<b>Pt</b>	platinum	<b>29</b>	<b>At</b>	(210)
<b>45</b>	<b>Ir</b>	iridium	<b>30</b>	<b>Bi</b>	(210)
<b>46</b>	<b>Au</b>	gold	<b>31</b>	<b>Te</b>	(210)
<b>47</b>	<b>Cd</b>	cadmium	<b>32</b>	<b>Pb</b>	(209.0)
<b>48</b>	<b>Hg</b>	mercury	<b>33</b>	<b>Bi</b>	(207.2)
<b>49</b>	<b>Ag</b>	silver	<b>34</b>	<b>Pb</b>	(204.4)
<b>50</b>	<b>In</b>	indium	<b>35</b>	<b>Te</b>	(204.4)
<b>51</b>	<b>Sb</b>	tin	<b>36</b>	<b>Te</b>	(202.6)
<b>52</b>	<b>Sn</b>	tin	<b>37</b>	<b>Br</b>	(202.6)
<b>53</b>	<b>Ge</b>	germanium	<b>38</b>	<b>Br</b>	(202.6)
<b>54</b>	<b>As</b>	arsenic	<b>39</b>	<b>Br</b>	(202.6)
<b>55</b>	<b>Ge</b>	germanium	<b>40</b>	<b>As</b>	(202.6)
<b>56</b>	<b>Ge</b>	germanium	<b>41</b>	<b>As</b>	(202.6)
<b>57</b>	<b>Ge</b>	germanium	<b>42</b>	<b>As</b>	(202.6)
<b>58</b>	<b>Ge</b>	germanium	<b>43</b>	<b>As</b>	(202.6)
<b>59</b>	<b>Ge</b>	germanium	<b>44</b>	<b>As</b>	(202.6)
<b>60</b>	<b>Ge</b>	germanium	<b>45</b>	<b>As</b>	(202.6)
<b>61</b>	<b>Ge</b>	germanium	<b>46</b>	<b>As</b>	(202.6)
<b>62</b>	<b>Ge</b>	germanium	<b>47</b>	<b>As</b>	(202.6)
<b>63</b>	<b>Ge</b>	germanium	<b>48</b>	<b>As</b>	(202.6)
<b>64</b>	<b>Ge</b>	germanium	<b>49</b>	<b>As</b>	(202.6)
<b>65</b>	<b>Ge</b>	germanium	<b>50</b>	<b>As</b>	(202.6)
<b>66</b>	<b>Ge</b>	germanium	<b>51</b>	<b>As</b>	(202.6)
<b>67</b>	<b>Ge</b>	germanium	<b>52</b>	<b>As</b>	(202.6)
<b>68</b>	<b>Ge</b>	germanium	<b>53</b>	<b>As</b>	(202.6)
<b>69</b>	<b>Ge</b>	germanium	<b>54</b>	<b>As</b>	(202.6)
<b>70</b>	<b>Ge</b>	germanium	<b>55</b>	<b>As</b>	(202.6)
<b>71</b>	<b>Ge</b>	germanium	<b>56</b>	<b>As</b>	(202.6)
<b>72</b>	<b>Ge</b>	germanium	<b>57</b>	<b>As</b>	(202.6)
<b>73</b>	<b>Ge</b>	germanium	<b>58</b>	<b>As</b>	(202.6)
<b>74</b>	<b>Ge</b>	germanium	<b>59</b>	<b>As</b>	(202.6)
<b>75</b>	<b>Ge</b>	germanium	<b>60</b>	<b>As</b>	(202.6)
<b>76</b>	<b>Ge</b>	germanium	<b>61</b>	<b>As</b>	(202.6)
<b>77</b>	<b>Ge</b>	germanium	<b>62</b>	<b>As</b>	(202.6)
<b>78</b>	<b>Ge</b>	germanium	<b>63</b>	<b>As</b>	(202.6)
<b>79</b>	<b>Ge</b>	germanium	<b>64</b>	<b>As</b>	(202.6)
<b>80</b>	<b>Ge</b>	germanium	<b>65</b>	<b>As</b>	(202.6)
<b>81</b>	<b>Ge</b>	germanium	<b>66</b>	<b>As</b>	(202.6)
<b>82</b>	<b>Ge</b>	germanium	<b>67</b>	<b>As</b>	(202.6)
<b>83</b>	<b>Ge</b>	germanium	<b>68</b>	<b>As</b>	(202.6)
<b>84</b>	<b>Ge</b>	germanium	<b>69</b>	<b>As</b>	(202.6)
<b>85</b>	<b>Ge</b>	germanium	<b>70</b>	<b>As</b>	(202.6)
<b>86</b>	<b>Ge</b>	germanium	<b>71</b>	<b>As</b>	(202.6)
<b>87</b>	<b>Ge</b>	germanium	<b>72</b>	<b>As</b>	(202.6)
<b>88</b>	<b>Ge</b>	germanium	<b>73</b>	<b>As</b>	(202.6)
<b>89</b>	<b>Ge</b>	germanium	<b>74</b>	<b>As</b>	(202.6)
<b>90</b>	<b>Ge</b>	germanium	<b>75</b>	<b>As</b>	(202.6)
<b>91</b>	<b>Ge</b>	germanium	<b>76</b>	<b>As</b>	(202.6)
<b>92</b>	<b>Ge</b>	germanium	<b>77</b>	<b>As</b>	(202.6)
<b>93</b>	<b>Ge</b>	germanium	<b>78</b>	<b>As</b>	(202.6)
<b>94</b>	<b>Ge</b>	germanium	<b>79</b>	<b>As</b>	(202.6)
<b>95</b>	<b>Ge</b>	germanium	<b>80</b>	<b>As</b>	(202.6)
<b>96</b>	<b>Ge</b>	germanium	<b>81</b>	<b>As</b>	(202.6)
<b>97</b>	<b>Ge</b>	germanium	<b>82</b>	<b>As</b>	(202.6)
<b>98</b>	<b>Ge</b>	germanium	<b>83</b>	<b>As</b>	(202.6)
<b>99</b>	<b>Ge</b>	germanium	<b>84</b>	<b>As</b>	(202.6)
<b>100</b>	<b>Ge</b>	germanium	<b>85</b>	<b>As</b>	(202.6)
<b>101</b>	<b>Ge</b>	germanium	<b>86</b>	<b>As</b>	(202.6)
<b>102</b>	<b>Ge</b>	germanium	<b>87</b>	<b>As</b>	(202.6)
<b>103</b>	<b>Ge</b>	germanium	<b>88</b>	<b>As</b>	(202.6)
<b>104</b>	<b>Ge</b>	germanium	<b>89</b>	<b>As</b>	(202.6)
<b>105</b>	<b>Ge</b>	germanium	<b>90</b>	<b>As</b>	(202.6)
<b>106</b>	<b>Ge</b>	germanium	<b>91</b>	<b>As</b>	(202.6)
<b>107</b>	<b>Ge</b>	germanium	<b>92</b>	<b>As</b>	(202.6)
<b>108</b>	<b>Ge</b>	germanium	<b>93</b>	<b>As</b>	(202.6)
<b>109</b>	<b>Ge</b>	germanium	<b>94</b>	<b>As</b>	(202.6)
<b>110</b>	<b>Ge</b>	germanium	<b>95</b>	<b>As</b>	(202.6)
<b>111</b>	<b>Ge</b>	germanium	<b>96</b>	<b>As</b>	(202.6)
<b>112</b>	<b>Ge</b>	germanium	<b>97</b>	<b>As</b>	(202.6)
<b>113</b>	<b>Ge</b>	germanium	<b>98</b>	<b>As</b>	(202.6)
<b>114</b>	<b>Ge</b>	germanium	<b>99</b>	<b>As</b>	(202.6)
<b>115</b>	<b>Ge</b>	germanium	<b>100</b>	<b>As</b>	(202.6)
<b>116</b>	<b>Ge</b>	germanium	<b>101</b>	<b>As</b>	(202.6)
<b>117</b>	<b>Ge</b>	germanium	<b>102</b>	<b>As</b>	(202.6)
<b>118</b>	<b>Ge</b>	germanium	<b>103</b>	<b>As</b>	(202.6)
<b>119</b>	<b>Ge</b>	germanium	<b>104</b>	<b>As</b>	(202.6)
<b>120</b>	<b>Ge</b>	germanium	<b>105</b>	<b>As</b>	(202.6)
<b>121</b>	<b>Ge</b>	germanium	<b>106</b>	<b>As</b>	(202.6)
<b>122</b>	<b>Ge</b>	germanium	<b>107</b>	<b>As</b>	(202.6)
<b>123</b>	<b>Ge</b>	germanium	<b>108</b>	<b>As</b>	(202.6)
<b>124</b>	<b>Ge</b>	germanium	<b>109</b>	<b>As</b>	(202.6)
<b>125</b>	<b>Ge</b>	germanium	<b>110</b>	<b>As</b>	(202.6)
<b>126</b>	<b>Ge</b>	germanium	<b>111</b>	<b>As</b>	(202.6)
<b>127</b>	<b>Ge</b>	germanium	<b>112</b>	<b>As</b>	(202.6)
<b>128</b>	<b>Ge</b>	germanium	<b>113</b>	<b>As</b>	(202.6)
<b>129</b>	<b>Ge</b>	germanium	<b>114</b>	<b>As</b>	(202.6)
<b>130</b>	<b>Ge</b>	germanium	<b>115</b>	<b>As</b>	(202.6)
<b>131</b>	<b>Ge</b>	germanium	<b>116</b>	<b>As</b>	(202.6)
<b>132</b>	<b>Ge</b>	germanium	<b>117</b>	<b>As</b>	(202.6)
<b>133</b>	<b>Ge</b>	germanium	<b>118</b>	<b>As</b>	(202.6)
<b>134</b>	<b>Ge</b>	germanium	<b>119</b>	<b>As</b>	(202.6)
<b>135</b>	<b>Ge</b>	germanium	<b>120</b>	<b>As</b>	(202.6)
<b>136</b>	<b>Ge</b>	germanium	<b>121</b>	<b>As</b>	(202.6)
<b>137</b>	<b>Ge</b>	germanium	<b>122</b>	<b>As</b>	(202.6)
<b>138</b>	<b>Ge</b>	germanium	<b>123</b>	<b>As</b>	(202.6)
<b>139</b>	<b>Ge</b>	germanium	<b>124</b>	<b>As</b>	(202.6)
<b>140</b>	<b>Ge</b>	germanium	<b>125</b>	<b>As</b>	(202.6)
<b>141</b>	<b>Ge</b>	germanium	<b>126</b>	<b>As</b>	(202.6)
<b>142</b>	<b>Ge</b>	germanium	<b>127</b>	<b>As</b>	(202.6)
<b>143</b>	<b>Ge</b>	germanium	<b>128</b>	<b>As</b>	(202.6)
<b>144</b>	<b>Ge</b>	germanium	<b>129</b>	<b>As</b>	(202.6)
<b>145</b>	<b>Ge</b>	germanium	<b>130</b>	<b>As</b>	(202.6)
<b>146</b>	<b>Ge</b>	germanium	<b>131</b>	<b>As</b>	(202.6)
<b>147</b>	<b>Ge</b>	germanium	<b>132</b>	<b>As</b>	(202.6)
<b>148</b>	<b>Ge</b>	germanium	<b>133</b>	<b>As</b>	(202.6)
<b>149</b>	<b>Ge</b>	germanium	<b>134</b>	<b>As</b>	(202.6)
<b>150</b>	<b>Ge</b>	germanium	<b>135</b>	<b>As</b>	(202.6)
<b>151</b>	<b>Ge</b>	germanium	<b>136</b>	<b>As</b>	(202.6)
<b>152</b>	<b>Ge</b>	germanium	<b>137</b>	<b>As</b>	(202.6)
<b>153</b>	<b>Ge</b>	germanium	<b>138</b>	<b>As</b>	(202.6)
<b>154</b>	<b>Ge</b>	germanium	<b>139</b>	<b>As</b>	(202.6)
<b>155</b>	<b>Ge</b>	germanium	<b>140</b>	<b>As</b>	(202.6)
<b>156</b>	<b>Ge</b>	germanium	<b>141</b>	<b>As</b>	(202.6)
<b>157</b>	<b>Ge</b>	germanium	<b>142</b>	<b>As</b>	(202.6)
<b>158</b>	<b>Ge</b>	germanium	<b>143</b>	<b>As</b>	(202.6)
<b>159</b>	<b>Ge</b>	germanium	<b>144</b>	<b>As</b>	(202.6)
<b>160</b>	<b>Ge</b>	germanium	<b>145</b>	<b>As</b>	(202.6)
<b>161</b>	<b>Ge</b>	germanium	<b>146</b>	<b>As</b>	(202.6)
<b>162</b>	<b>Ge</b>	germanium	<b>147</b>	<b>As</b>	(202.6)
<b>163</b>	<b>Ge</b>	germanium	<b>148</b>	<b>As</b>	(202.6)
<b>164</b>	<b>Ge</b>	germanium	<b>149</b>	<b>As</b>	(202.6)
<b>165</b>	<b>Ge</b>	germanium	<b>150</b>	<b>As</b>	(202.6)
<b>166</b>	<b>Ge</b>	germanium	<b>151</b>	<b>As</b>	(202.6)
<b>167</b>	<b>Ge</b>	germanium	<b>152</b>	<b>As</b>	(202.6)
<b>168</b>	<b>Ge</b>	germanium	<b>153</b>	<b>As</b>	(202.6)
<b>169</b>	<b>Ge</b>	germanium	<b>154</b>	<b>As</b>	(202.6)
<b>170</b>	<b>Ge</b>	germanium	<b>155</b>	<b>As</b>	(202.6)
<b>171</b>	<b>Ge</b>	germanium	<b>156</b>	<b>As</b>	(202.6)
<b>172</b>	<b>Ge</b>	germanium	<b>157</b>	<b>As</b>	(202.6)
<b>173</b>	<b>Ge</b>	germanium	<b>158</b>	<b>As</b>	(202.6)
<b>174</b>	<b>Ge</b>	germanium	<b>159</b>	<b>As</b>	(202.6)
<b>175</b>	<b>Ge</b>	germanium	<b>160</b>	<b>As</b>	(202.6)
<b>176</b>	<b>Ge</b>	germanium	<b>161</b>	<b>As</b>	(202.6)
<b>177</b>	<b>Ge</b>	germanium	<b>162</b>	<b>As</b>	(202.6)
<b>178</b>	<b>Ge</b>	germanium	<b>163</b>	<b>As</b>	(202.6)
<b>179</b>	<b>Ge</b>	germanium	<b>164</b>	<b>As</b>	(202.6)
<b>180</b>	<b>Ge</b>	germanium	<b>165</b>	<b>As</b>	(202.6)
<b>181</b>	<b>Ge</b>	germanium	<b>166</b>	<b>As</b>	(202.6)
<b>182</b>	<b>Ge</b>	germanium	<b>167</b>	<b>As</b>	(202.6)
<b>183</b>	<b>Ge</b>	germanium	<b>168</b>	<b>As</b>	(202.6)
<b>184</b>	<b>Ge</b>	germanium	<b>169</b>	<b>As</b>	(202.6)
<b>185</b>	<b>Ge</b>	germanium	<b>170</b>	<b>As</b>	(202.6)
<b>186</b>	<b>Ge</b>	germanium	<b>171</b>	<b>As</b>	(202.6)
<b>187</b>	<b>Ge</b>	germanium	<b>172</b>	<b>As</b>	(202.6)
<b>188</b>	<b>Ge</b>	germanium	<b>173</b>	<b>As</b>	(202.6)
<b>189</b>	<b>Ge</b>	germanium	<b>174</b>	<b>As</b>	(202.6)
<b>190</b>	<b>Ge</b>	germanium	<b>175</b>	<b>As</b>	(202.6)
<b>191</b>	<b>Ge</b>	germanium	<b>176</b>	<b>As</b>	(202.6)
<b>192</b>	<b>Ge</b>	germanium	<b>177</b>	<b>As</b>	(202.6)
<b>193</b>	<b>Ge</b>	germanium	<b>178</b>	<b>As</b>	(202.6)
<b>194</b>	<b>Ge</b>	germanium	<b>179</b>	<b>As</b>	(202.6)
<b>195</b>	<b>Ge</b>	germanium	<b>180</b>	<b>As</b>	(202.6)
<b>196</b>	<b>Ge</b>	germanium	<b>181</b>	<b>As</b>	(202.6)
<b>197</b>	<b>Ge</b>	germanium	<b>182</b>	<b>As</b>	(202.6)
<b>198</b>	<b>Ge</b>	germanium	<b>183</b>	<b>As</b>	(202.6)
<b>199</b>	<b>Ge</b>	germanium	<b>184</b>	<b>As</b>	(202.6)
<b>200</b>	<b>Ge</b>	germanium	<b>185</b>	<b>As</b>	(202.6)
<b>201</b>	<b>Ge</b>	germanium	<b>186</b>	<b>As</b>	(202.6)
<b>202</b>	<b></b>				

<b>57</b>	<b>58</b>	<b>59</b>	<b>60</b>	<b>61</b>	<b>62</b>	<b>63</b>	<b>64</b>	<b>65</b>	<b>66</b>	<b>67</b>	<b>68</b>	<b>69</b>	<b>70</b>	<b>71</b>
La 138.9	Ce 140.1	Pr 140.9	Nd 144.2	Pm (145)	Sm 150.4	Eu 152.0	Gd 157.3	Tb 158.9	Dy 162.5	Ho 164.9	Er 167.3	Tm 168.9	Yb 173.1	Lu 175.0
lanthanum	cerium	praseodymium	neodymium	promethium	samarium	europtium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	yterbium	lutetium
<b>89</b>	<b>90</b>	<b>91</b>	<b>92</b>	<b>93</b>	<b>94</b>	<b>95</b>	<b>96</b>	<b>97</b>	<b>98</b>	<b>99</b>	<b>100</b>	<b>101</b>	<b>102</b>	<b>103</b>
Ac (227)	Th 232.0	Pa 231.0	U 238.0	Np (237)	Pu (244)	Am (243)	Cm (247)	Bk (247)	Cf (251)	Es (252)	Fm (257)	Md (258)	No (259)	Lr (262)
actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	einsteinium	californium	fonium	mendelevium	nobelium	lawrencium

The value in brackets indicates the mass number of the longest-lived isotope.

## 2. Electrochemical series

Reaction	Standard electrode potential ( $E^0$ ) in volts at 25 °C
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightleftharpoons Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	+1.23
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O_2(aq)$	+0.68
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	+0.15
$S(s) + 2H^+(aq) + 2e^- \rightleftharpoons H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	-0.13
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	-0.14
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	-0.25
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	-0.28
$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$	-0.40
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	-0.44
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	-0.76
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	-0.83
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	-1.18
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	-1.66
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	-2.37
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	-2.71
$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s)$	-2.87
$K^+(aq) + e^- \rightleftharpoons K(s)$	-2.93
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	-3.04

### 3. Chemical relationships

Name	Formula
number of moles of a substance	$n = \frac{m}{M}; \quad n = cV; \quad n = \frac{V}{V_m}$
universal gas equation	$pV = nRT$
calibration factor (CF) for bomb calorimetry	$CF = \frac{VIt}{\Delta T}$
heat energy released in the combustion of a fuel	$q = mc\Delta T$
enthalpy of combustion	$\Delta H = \frac{q}{n}$
electric charge	$Q = It$
number of moles of electrons	$n(e^-) = \frac{Q}{F}$
% atom economy	$\frac{\text{molar mass of desired product}}{\text{molar mass of all reactants}} \times \frac{100}{1}$
% yield	$\frac{\text{actual yield}}{\text{theoretical yield}} \times \frac{100}{1}$

### 4. Physical constants and standard values

Name	Symbol	Value
Avogadro constant	$N_A$ or $L$	$6.02 \times 10^{23} \text{ mol}^{-1}$
charge on one electron (elementary charge)	$e$	$-1.60 \times 10^{-19} \text{ C}$
Faraday constant	$F$	$96\,500 \text{ C mol}^{-1}$
molar gas constant	$R$	$8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
molar volume of an ideal gas at SLC (25 °C and 100 kPa)	$V_m$	$24.8 \text{ L mol}^{-1}$
specific heat capacity of water	$c$	$4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ or $4.18 \text{ J g}^{-1} \text{ K}^{-1}$
density of water at 25 °C	$d$	$997 \text{ kg m}^{-3}$ or $0.997 \text{ g mL}^{-1}$

## 5. Unit conversions

Measured value	Conversion
0 °C	273 K
100 kPa	750 mm Hg or 0.987 atm
1 litre (L)	1 dm <sup>3</sup> or $1 \times 10^{-3}$ m <sup>3</sup> or $1 \times 10^3$ cm <sup>3</sup> or $1 \times 10^3$ mL

## 6. Metric (including SI) prefixes

Metric (including SI) prefixes	Scientific notation	Multiplying factor
giga (G)	$10^9$	1 000 000 000
mega (M)	$10^6$	1 000 000
kilo (k)	$10^3$	1000
deci (d)	$10^{-1}$	0.1
centi (c)	$10^{-2}$	0.01
milli (m)	$10^{-3}$	0.001
micro ( $\mu$ )	$10^{-6}$	0.000001
nano (n)	$10^{-9}$	0.000000001
pico (p)	$10^{-12}$	0.000000000001

## 7. Acid-base indicators

Name	pH range	Colour change from lower pH to higher pH in range
thymol blue (1st change)	1.2–2.8	red → yellow
methyl orange	3.1–4.4	red → yellow
bromophenol blue	3.0–4.6	yellow → blue
methyl red	4.4–6.2	red → yellow
bromothymol blue	6.0–7.6	yellow → blue
phenol red	6.8–8.4	yellow → red
thymol blue (2nd change)	8.0–9.6	yellow → blue
phenolphthalein	8.3–10.0	colourless → pink

## 8. Representations of organic molecules

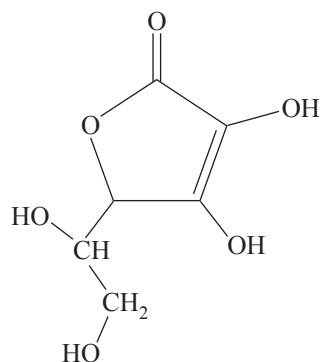
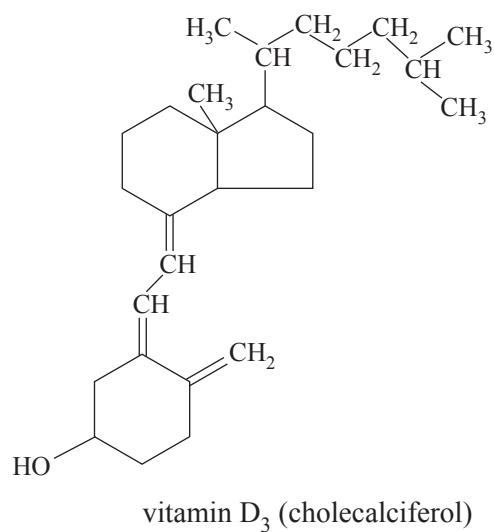
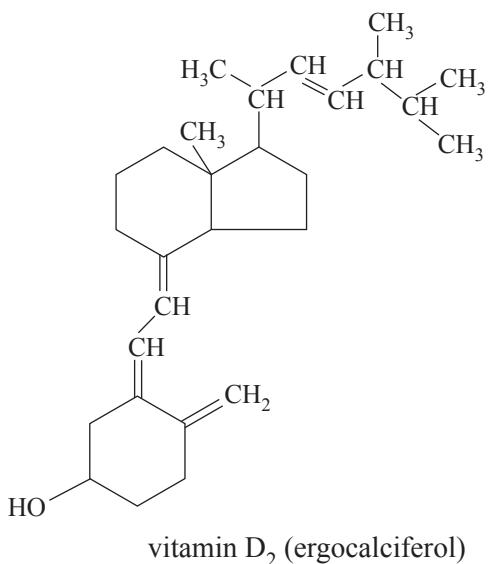
The following table shows different representations of organic molecules, using butanoic acid as an example.

Formula	Representation
molecular formula	$C_4H_8O_2$
structural formula	$  \begin{array}{ccccccc}  & H & H & H & & O & \\  &   &   &   & & \parallel & \\  H & - C & - C & - C & - C & = O & \\  &   &   &   & & / & \\  & H & H & H & & O - H &  \end{array}  $
semi-structural (condensed) formula	$CH_3CH_2CH_2COOH$ or $CH_3(CH_2)_2COOH$
skeletal structure	

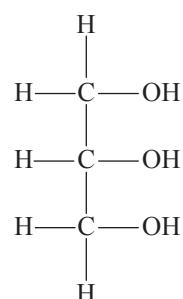
## 9. Formulas of some fatty acids

Name	Formula	Semi-structural formula
lauric	$C_{11}H_{23}COOH$	$CH_3(CH_2)_{10}COOH$
myristic	$C_{13}H_{27}COOH$	$CH_3(CH_2)_{12}COOH$
palmitic	$C_{15}H_{31}COOH$	$CH_3(CH_2)_{14}COOH$
palmitoleic	$C_{15}H_{29}COOH$	$CH_3(CH_2)_4CH_2CH=CHCH_2(CH_2)_5CH_2COOH$
stearic	$C_{17}H_{35}COOH$	$CH_3(CH_2)_{16}COOH$
oleic	$C_{17}H_{33}COOH$	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$
linoleic	$C_{17}H_{31}COOH$	$CH_3(CH_2)_4(CH=CHCH_2)_2(CH_2)_6COOH$
linolenic	$C_{17}H_{29}COOH$	$CH_3CH_2(CH=CHCH_2)_3(CH_2)_6COOH$
arachidic	$C_{19}H_{39}COOH$	$CH_3(CH_2)_{17}CH_2COOH$
arachidonic	$C_{19}H_{31}COOH$	$CH_3(CH_2)_4(CH=CHCH_2)_3CH=CH(CH_2)_3COOH$

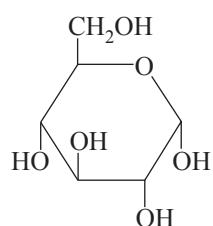
## 10. Formulas of some biomolecules



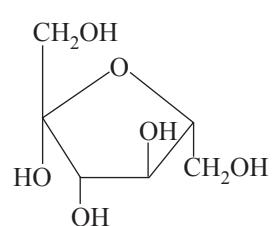
vitamin C (ascorbic acid)



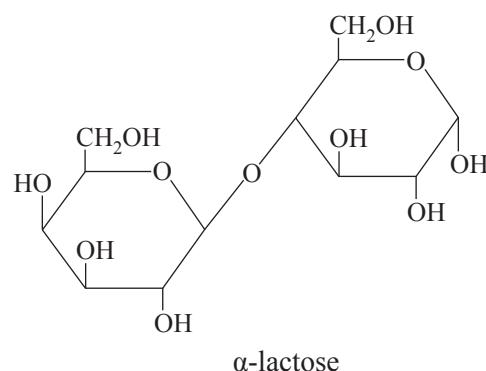
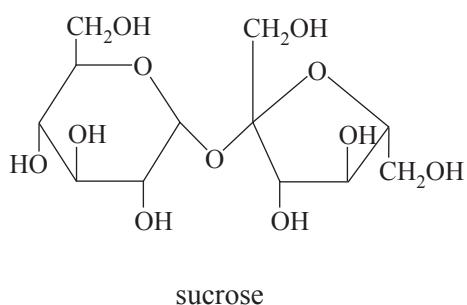
glycerol

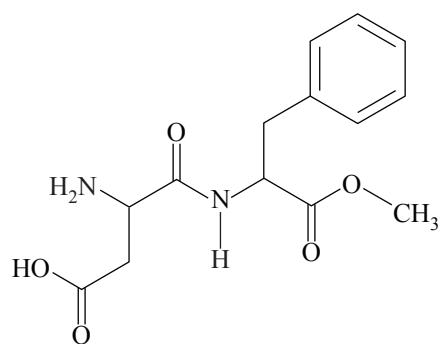


α-glucose

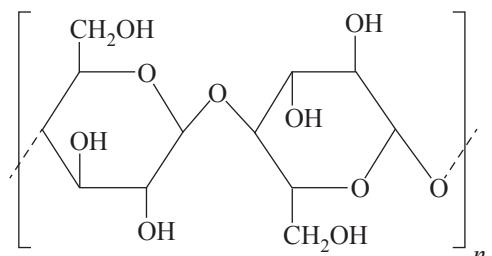


β-fructose

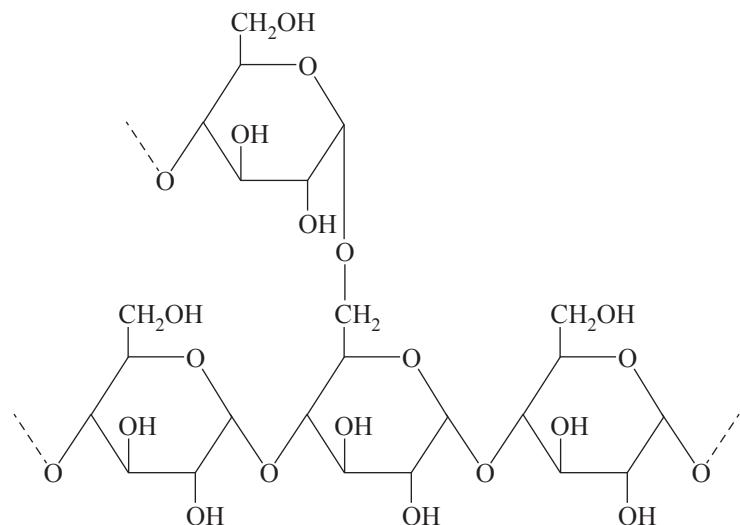




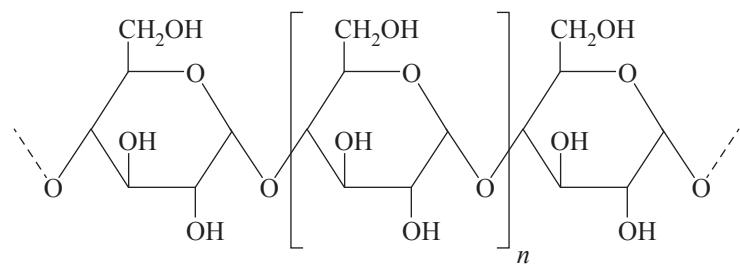
aspartame



cellulose



amylopectin (starch)



amylose (starch)

## 11. Heats of combustion of common fuels

The heats of combustion in the following table are calculated at SLC (25 °C and 100 kPa) with combustion products being CO<sub>2</sub> and H<sub>2</sub>O. Heat of combustion may be defined as the heat energy released when a specified amount of a substance burns completely in oxygen and is, therefore, reported as a positive value, indicating a magnitude. Enthalpy of combustion,  $\Delta H$ , for the substances in this table would be reported as negative values, indicating the exothermic nature of the combustion reaction.

Fuel	Formula	State	Heat of combustion (kJ g <sup>-1</sup> )	Molar heat of combustion (kJ mol <sup>-1</sup> )
hydrogen	H <sub>2</sub>	gas	141	282
methane	CH <sub>4</sub>	gas	55.6	890
ethane	C <sub>2</sub> H <sub>6</sub>	gas	51.9	1560
propane	C <sub>3</sub> H <sub>8</sub>	gas	50.5	2220
butane	C <sub>4</sub> H <sub>10</sub>	gas	49.7	2880
octane	C <sub>8</sub> H <sub>18</sub>	liquid	47.9	5460
ethyne (acetylene)	C <sub>2</sub> H <sub>2</sub>	gas	49.9	1300
methanol	CH <sub>3</sub> OH	liquid	22.7	726
ethanol	C <sub>2</sub> H <sub>5</sub> OH	liquid	29.6	1360

## 12. Heats of combustion of common blended fuels

Blended fuels are mixtures of compounds with different mixture ratios and, hence, determination of a generic molar enthalpy of combustion is not realistic. The values provided in the following table are typical values for heats of combustion at SLC (25 °C and 100 kPa) with combustion products being CO<sub>2</sub> and H<sub>2</sub>O. Values for heats of combustion will vary depending on the source and composition of the fuel.

Fuel	State	Heat of combustion (kJ g <sup>-1</sup> )
kerosene	liquid	46.2
diesel	liquid	45.0
natural gas	gas	54.0

## 13. Energy content of food groups

Food	Heat of combustion (kJ g <sup>-1</sup> )
fats and oils	37
protein	17
carbohydrate	16

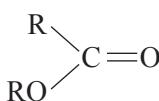
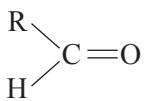
## 14. Characteristic ranges for infra-red absorption

Bond	Wave number (cm <sup>-1</sup> )	Bond	Wave number (cm <sup>-1</sup> )
C–Cl (chloroalkanes)	600–800	C=O (ketones)	1680–1850
C–O (alcohols, esters, ethers)	1050–1410	C=O (esters)	1720–1840
C=C (alkenes)	1620–1680	C–H (alkanes, alkenes, arenes)	2850–3090
C=O (amides)	1630–1680	O–H (acids)	2500–3500
C=O (aldehydes)	1660–1745	O–H (alcohols)	3200–3600
C=O (acids)	1680–1740	N–H (amines and amides)	3300–3500

## 15. <sup>13</sup>C NMR data

Typical <sup>13</sup>C shift values relative to TMS = 0

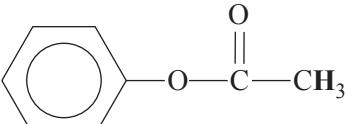
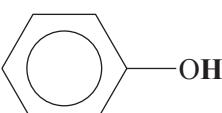
These can differ slightly in different solvents.

Type of carbon	Chemical shift (ppm)
R–CH <sub>3</sub>	8–25
R–CH <sub>2</sub> –R	20–45
R <sub>3</sub> –CH	40–60
R <sub>4</sub> –C	36–45
R–CH <sub>2</sub> –X	15–80
R <sub>3</sub> C–NH <sub>2</sub> , R <sub>3</sub> C–NR	35–70
R–CH <sub>2</sub> –OH	50–90
RC≡CR	75–95
R <sub>2</sub> C=CR <sub>2</sub>	110–150
RCOOH	160–185
	165–175
	190–200
R <sub>2</sub> C=O	205–220

## 16. $^1\text{H}$ NMR data

Typical proton shift values relative to TMS = 0

These can differ slightly in different solvents. The shift refers to the proton environment that is indicated in bold letters in the formula.

Type of proton	Chemical shift (ppm)
$\text{R}-\text{CH}_3$	0.9–1.0
$\text{R}-\text{CH}_2-\text{R}$	1.3–1.4
$\text{RCH}=\text{CH}-\text{CH}_3$	1.6–1.9
$\text{R}_3-\text{CH}$	1.5
$\begin{array}{c} \text{CH}_3-\text{C}=\text{O} \\   \\ \text{OR} \end{array}$ or $\begin{array}{c} \text{CH}_3-\text{C}=\text{O} \\   \\ \text{NHR} \end{array}$	2.0
$\begin{array}{c} \text{CH}_3 \\   \\ \text{R}-\text{C}=\text{O} \\   \\ \text{O} \end{array}$	2.1–2.7
$\text{R}-\text{CH}_2-\text{X}$ ( $\text{X} = \text{F}, \text{Cl}, \text{Br}$ or $\text{I}$ )	3.0–4.5
$\text{R}-\text{CH}_2-\text{OH}$ , $\text{R}_2-\text{CH}-\text{OH}$	3.3–4.5
$\begin{array}{c} \text{O} \\    \\ \text{R}-\text{C}-\text{NHCH}_2\text{R} \end{array}$	3.2
$\text{R}-\text{O}-\text{CH}_3$ or $\text{R}-\text{O}-\text{CH}_2\text{R}$	3.3–3.7
	2.3
$\begin{array}{c} \text{O} \\    \\ \text{R}-\text{C}-\text{OCH}_2\text{R} \end{array}$	3.7–4.8
$\text{R}-\text{O}-\text{H}$	1–6 (varies considerably under different conditions)
$\text{R}-\text{NH}_2$	1–5
$\text{RHC}\equiv\text{CHR}$	4.5–7.0
	4.0–12.0

Type of proton	Chemical shift (ppm)
	6.9–9.0
$\text{R}-\text{C}(=\text{O})-\text{NHCH}_2\text{R}$	8.1
$\text{R}-\text{C}(=\text{O})-\text{H}$	9.4–10.0
$\text{R}-\text{C}(=\text{O})-\text{O}-\text{H}$	9.0–13.0

## 17. 2-amino acids ( $\alpha$ -amino acids)

The table below provides simplified structures to enable the drawing of zwitterions, the identification of products of protein hydrolysis and the drawing of structures involving condensation polymerisation of amino acid monomers.

Name	Symbol	Structure
alanine	Ala	$\begin{array}{c} \text{CH}_3 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
arginine	Arg	$\begin{array}{c} & \text{NH} \\ &    \\ \text{CH}_2—\text{CH}_2—\text{CH}_2—\text{NH}—\text{C}—\text{NH}_2 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
asparagine	Asn	$\begin{array}{c} & \text{O} \\ &    \\ \text{CH}_2—\text{C}—\text{NH}_2 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
aspartic acid	Asp	$\begin{array}{c} \text{CH}_2—\text{COOH} \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
cysteine	Cys	$\begin{array}{c} \text{CH}_2—\text{SH} \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
glutamic acid	Glu	$\begin{array}{c} \text{CH}_2—\text{CH}_2—\text{COOH} \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
glutamine	Gln	$\begin{array}{c} & \text{O} \\ &    \\ \text{CH}_2—\text{CH}_2—\text{C}—\text{NH}_2 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
glycine	Gly	$\text{H}_2\text{N}—\text{CH}_2—\text{COOH}$
histidine	His	$\begin{array}{c} & \text{N} \\ &    \\ \text{CH}_2—\text{C}—\text{N}—\text{H} \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
isoleucine	Ile	$\begin{array}{c} \text{CH}_3—\text{CH}—\text{CH}_2—\text{CH}_3 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$

Name	Symbol	Structure
leucine	Leu	$\begin{array}{c} \text{CH}_3—\text{CH}—\text{CH}_3 \\   \\ \text{CH}_2 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
lysine	Lys	$\begin{array}{c} \text{CH}_2—\text{CH}_2—\text{CH}_2—\text{CH}_2—\text{NH}_2 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
methionine	Met	$\begin{array}{c} \text{CH}_2—\text{CH}_2—\text{S}—\text{CH}_3 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
phenylalanine	Phe	$\begin{array}{c} \text{CH}_2—\text{C}_6\text{H}_5 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
proline	Pro	$\begin{array}{c} \text{HN} \\   \\ \text{CH}_2 \\   \\ \text{COOH} \end{array}$
serine	Ser	$\begin{array}{c} \text{CH}_2—\text{OH} \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
threonine	Thr	$\begin{array}{c} \text{CH}_3—\text{CH}—\text{OH} \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
tryptophan	Trp	$\begin{array}{c} \text{HN} \\   \\ \text{CH}_2 \\   \\ \text{C}_6\text{H}_5 \end{array}$ $\begin{array}{c} \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
tyrosine	Tyr	$\begin{array}{c} \text{CH}_2—\text{C}_6\text{H}_4—\text{OH} \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$
valine	Val	$\begin{array}{c} \text{CH}_3—\text{CH}—\text{CH}_3 \\   \\ \text{H}_2\text{N}—\text{CH}—\text{COOH} \end{array}$



# Edrolo

## Chemistry Units 3&4

Practice written examination

### MULTIPLE-CHOICE ANSWER SHEET

DATE: \_\_\_\_\_

STUDENT NAME: \_\_\_\_\_

TEACHER NAME: \_\_\_\_\_

#### Instructions

Use a **pencil** for **all** entries. For each question, shade the box which indicates your answer.

Marks will **not** be deducted for incorrect answers.

**No mark** will be given if more than **one** answer is completed for any question.

If you make a mistake, **erase** the incorrect answer - **do not** cross it out.

All answers must be completed like this example: **A** **B** **C** **D**

One answer per line		One answer per line		One answer per line	
1	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	11	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	21	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
2	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	12	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	22	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
3	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	13	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	23	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
4	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	14	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	24	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
5	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	15	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	25	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
6	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	16	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	26	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
7	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	17	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	27	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
8	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	18	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	28	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
9	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	19	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	29	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D
10	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	20	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D	30	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D