Stage 2 Chemistry

Skills and Applications Tasks

SACE ID _____

Time 80 minutes

- Questions 1 to 6, 74 marks
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on the space provided on the last page if you need more space

PERIODIC TABLE OF THE ELEMENTS

1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminium 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.90	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.70	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (97)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Caesium 132.9	56 Ba Barium 137.3	57[1] La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89[2] Ac Actinium (227)	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (271)	107 Bh Bohrium (272)	108 Hs Hassium (270)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

[1]Lanthanide Series	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
[2]Actinide Series	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

You may remove this page from the booklet by tearing along the perforations.

PLEASE TURN OVER

Metal activity

K	*most reactive*
Ca	
Na	
Mg	
Al	
Zn	
Cd	
Co	
Ni	
Bi	
Cu	
Hg	
Ag	
Au	*least reactive*

Table of SI prefixes

SI prefix	*Symbol*	*Value*
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Symbols of common quantities

amount of substance	n
mass	m
molar concentration	c
change in enthalpy	ΔH
molar mass	M
volume	V
heat energy	Q
specific heat capacity	C
temperature	T

Magnitude of physical constants

Avogadro's number	6.02×10^{23} mol^{-1}
heat capacity of water	4.18 J g^{-1} K^{-1}

Mathematical relationships

$$n = \frac{m}{M}$$

$$c = \frac{n}{V}$$

$$Q = mC\Delta T$$

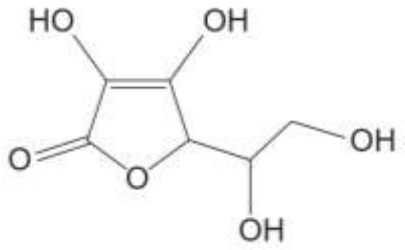
$$\Delta H = \frac{Q}{n}$$

$$pH = -\log\left[H^{+}\right]$$

Question 2 (14 marks)

Vitamin C is found in many fruits and vegetables.

(a) The structural formula of vitamin C is shown below.

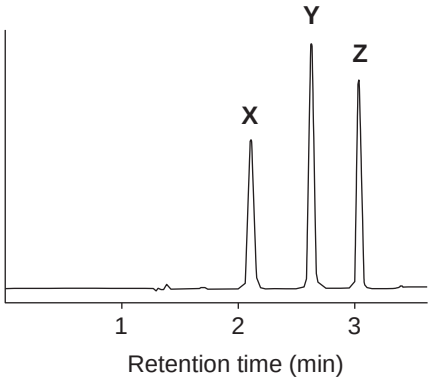


(i) Name *two* functional groups, other than hydroxyl groups, that are present in vitamin C.

_____

_____ (2 marks)

(ii) A mixture of three vitamins was analysed by chromatography, using a non-polar stationary phase and a polar mobile phase. Vitamin C is the most polar vitamin in the mixture.
The chromatogram below shows the three peaks obtained (**X**, **Y**, and **Z**).



State and explain which peak corresponds to vitamin C.

_____

_____

_____

_____

_____

_____ (3 marks)

Credit will be given for the correct use of significant figures in answers to part (b). (1 mark)

(b) The concentration of vitamin C, $C_6H_8O_6$, in one fruit juice was determined by titration with a solution of I_3^-, using the following procedure:

Step 1 A 20.00 mL sample of fruit juice was diluted to 200.0 mL with distilled water in a volumetric flask.

Step 2 25.00 mL of this diluted fruit juice was placed into a conical flask and titrated with a 2.400×10^{-4} mol L^{-1} solution of I_3^-. The equation for this reaction is shown below.

$$C_6H_8O_{6(aq)} + I_3^-{}_{(aq)} \longrightarrow C_6H_6O_{6(aq)} + 2H^+_{(aq)} + 3I^-_{(aq)}$$

Step 3 Step 2 was then repeated twice. An average titre of 15.65 mL was obtained.

(i) Calculate the number of moles of I_3^- present in the average titre.

(2 marks)

(ii) Determine the number of moles of vitamin C present in 25.00 mL of the *diluted* fruit juice.

(1 mark)

(iii) Calculate the concentration, in mg L^{-1}, of vitamin C (M = 176.124 g mol^{-1}) in the *undiluted* sample of fruit juice.

(4 marks)

(iv) State why an average titre produced from only three titrations could be considered to be reliable.

_____

_____ (1 mark)

Question 3 (13 marks)

Blood alcohol levels can be measured using breath-testing instruments. When a person blows continuously into one type of breath-testing instrument, ethanol present in the person's breath undergoes oxidation, producing an electrical current that can be measured and converted into a blood alcohol reading. This type of breath-testing instrument is classified as a fuel cell.

(a) Explain whether a fuel cell is an electrolytic cell or a galvanic cell.

(2 marks)

(b) Explain how the operation of this type of breath-testing instrument identifies it as a fuel cell.

(2 marks)

(c) Oxidation of ethanol occurs in two steps.

(i) Complete and balance the half-equation below to show the *first* step.

$$C_2H_5OH \longrightarrow CH_3CHO$$

(2 marks)

(ii) State the systematic name of the product formed in the *second* step.

(1 mark)

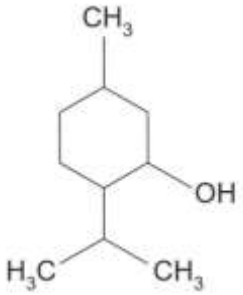
(d) The pH of the electrolyte in one fuel cell is 3.8.

Calculate the hydrogen ion concentration, in mol L^{-1}, in the electrolyte.

(2 marks)

(e) Other alcohols present in a person's breath at the time of testing may add to the blood alcohol reading.

(i) Some cough medications contain the alcohol menthol. The structure of menthol is shown below.



(1) Classify menthol as a primary alcohol or a secondary alcohol.

_____ (1 mark)

(2) Draw the structural formula of the product that forms when menthol is oxidised.

(2 marks)

(ii) State why the presence of a tertiary alcohol in a person's breath would ***not*** add to the blood alcohol reading.

_____

_____ (1 mark)

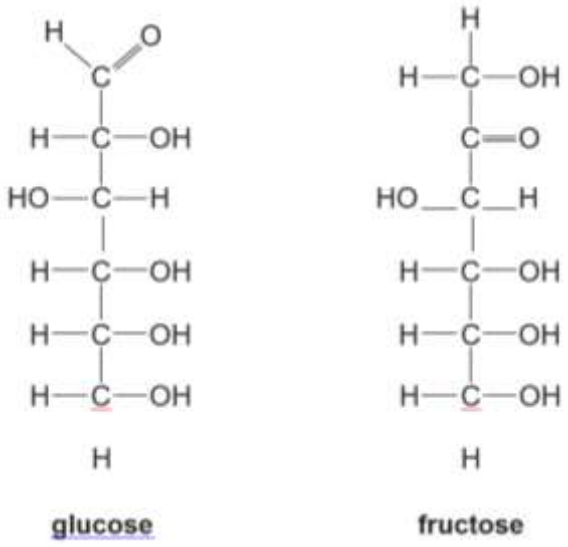
Question 4 (16 marks)

Glucose and fructose are fermentable sugars in grape juice, which is used to make wine.

(a) Write the equation for the fermentation of glucose in grape juice.

(2 marks)

(b) Glucose and fructose are isomers, having the same molecular formula. The structural formulae of glucose and fructose are shown below.



(i) State whether glucose and fructose are monosaccharides, disaccharides, or polysaccharides.

(1 mark)

(ii) State why glucose and fructose are chemically different compounds.

_____ (1 mark)

(iii) Samples of glucose and fructose were tested with Tollens' reagent.

(1) State the observation that indicates a positive result.

_____ (1 mark)

(2) (A) State whether you would expect a positive result or a negative result for glucose.

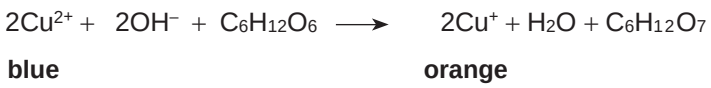
_____ (1 mark)

(B) State whether you would expect a positive result or a negative result for fructose.

_____ (1 mark)

(c) The sugar concentration of wine can be measured using tablets that contain copper (II) ions.

(i) Blue copper (II) ions in alkaline solution react with sugars present in wine to form orange copper (I) ions, as shown in the equation below.



Write the formula of the oxidising agent in this reaction.

_____ (1 mark)

(ii) In order to test the sugar concentration of a wine, one of these tablets is added to a test tube that contains a 0.50 mL sample of wine. The resulting solution varies in colour according to its sugar concentration.

The table below is used to determine sugar concentration, and hence wine category, from the colour of the solution.

Colour	*Sugar concentration (%)*	*Wine category*
blue	0–0.1	control
olive green	0.1–0.2	dry white
dark brown	0.2–0.3	dry red
orange-brown	0.3–3.0	off-dry
orange	>3	sweet

(1) The sugar concentration of one sample of wine was determined to be 0.15%.

(A) Identify the wine category of this sample of wine.

_____ (1 mark)

(B) Convert this concentration to g L^{-1}.

(2 marks)

(2) The sugar concentration of another sample of wine was found to be 1.8 g L^{-1}.

Assume that the only sugars present in this sample of wine are glucose and fructose, and that these sugars are present in equal amounts.

Calculate the concentration of glucose, in mol L^{-1}, in this sample.

(3 marks)

(i) These tablets also react with compounds that occur naturally in red wine. Consequently, sugar concentration estimates of red wine obtained through this method are overestimated.

Identify whether the error in the estimated sugar concentration of a red wine sample is a random error or a systematic error.

_____

(1 mark)

Question 5 (13 marks)

Beeswax is a mixture of many organic compounds, including hentriacontane, cerotic acid, and triacontanol.

(a) Hentriacontane, $C_{31}H_{64}$, is a long-chain hydrocarbon found in beeswax. The structural formula of hentriacontane is shown below.

(i) State whether hentriacontane is a saturated or an unsaturated hydrocarbon.

_____ (1 mark)

(ii) (1) Identify *one* reagent that could be used to test hentriacontane for unsaturation.

_____ (1 mark)

(2) State the expected observation when hentriacontane is tested with this reagent.

_____

_____ (1 mark)

(b) The structural formulae of cerotic acid and triacontanol are shown below.

cerotic acid **triacontanol**

(i) Cerotic acid and triacontanol react to form an ester that is also present in beeswax.

(1) Draw the structural formula of this ester.

(2 marks)

(2) Predict and explain whether this ester would have a higher melting point or a lower melting point than hentriacontane.

(3 marks)

(ii) Triacontanol is a compound that promotes plant growth by increasing the rate of photosynthesis.

(1) Write an equation for the process of photosynthesis.

(2 marks

(2) Explain one advantage to the environment of increasing the rate of photosynthesis in plants.

(3 marks)