PERTH MODERN SCHOOL
Exceptional schooling. Exceptional students.
INDEPENDENT PUBLIC SCHOOL

**Year 11 Unit 1 Examination, 2017**

**Question/Answer Booklet**

# CHEMISTRY

# Marking Key

### Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: two and a half hours

**Multiple-Choice Questions: ANSWERS**

| Question | Answer |
|---|---|
| 1 | A |
| 2 | D |
| 3 | C |
| 4 | B |
| 5 | D |
| 6 | D |
| 7 | A |
| 8 | D |
| 9 | B |
| 10 | A |
| 11 | B |
| 12 | C |
| 13 | C |
| 14 | D |
| 15 | C |
| 16 | D |
| 17 | C |
| 18 | C |
| 19 | C |
| 20 | D |

**Section One: Multiple-choice** **25% (40 Marks)**

This section has **20** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 40 minutes.

---

1. Which one of the following has the same electron configuration as a chloride ion?

   (a) argon
   (b) potassium
   (c) sulfur
   (d) magnesium

2. Which one of the following statements best describes the similarities and differences between isotopes of an element?

   (a) Isotopes have the same electron configuration but different atomic number.
   (b) Isotopes have similar chemical properties but differ in their electron configuration.
   (c) Isotopes have the same number of protons and neutrons but differ in their electron configuration.
   (d) Isotopes have similar chemical properties but different physical properties.

3. Which one of the elements listed below is most similar in chemical and physical properties to element number 52?

   (a) chromium
   (b) antimony
   (c) selenium
   (d) iodine

4. Which one of the following electron configurations would represent a non-metal in Group 15?

   (a) 2, 8, 3
   (b) 2, 5
   (c) 2, 8, 2
   (d) 2, 7

5. Which one of the following statements about nanomaterials is **false**?

(a) Nanomaterials are substances that contain particles with specific properties which may differ from those of the equivalent bulk material.
(b) Nanomaterials are materials made of nano-particles which range from 1 – 100 nm in size.
(c) Fullerene, an allotrope of carbon, can be used to make nanomaterials.
(d) Nanomaterials are substances that contain only particles of 1 nm in size.

6. Which one of the following is the correct formula for calcium phosphate?

(a) $CaPO_4$
(b) $Ca_3(PO)_4$
(c) $Ca_2PO_2$
(d) $Ca_3(PO_4)_2$

7. Which one of the elements has 4 valence electrons?

(a) silicon
(b) aluminium
(c) lithium
(d) sulfur

8. Which of the following is the electronic configuration for the sulfide ion, $S^{2-}$?

(a) $1s^2\ 2s^2\ 3s^6\ 2p^2\ 3p^6$
(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

9. Which of these is the best explanation as to why covalent molecular substances **cannot** conduct electricity in either the solid or liquid form?

(a) Their low melting points mean they melt easily when an electrical current is applied.
(b) There are no charged particles able to move through their structure.
(c) They have very weak intermolecular forces of attraction.
(d) The bonding of covalent molecular substances involves sharing electrons.

10. Which one of following is the best explanation as to why ionic substances conduct electricity in both the molten and aqueous form?

(a) In both the molten and aqueous solution ionic substances have mobile ions.
(b) In both the molten and aqueous solution ionic substances have mobile electrons.
(c) Ionic bonding is similar to metallic bonding in that when molten and aqueous they both have freely moving electrons.
(d) Ionic substances have high melting points and are brittle.

11. Separating pure water from salt water can be done by:

(a) evaporation.
(b) distillation.
(c) decantation.
(d) filtration.

12. Which two of these species represent an element, and its positive ion?

| Species | Number of protons | Number of electrons | Number of neutrons |
|---|---|---|---|
| 1 | 11 | 11 | 12 |
| 2 | 12 | 12 | 12 |
| 3 | 12 | 10 | 13 |
| 4 | 11 | 11 | 13 |

(a) 1 and 2
(b) 1 and 3
(c) 2 and 3
(d) 2 and 4

13. Which one of these lists of chemical formulas represents **molecular compounds** only?

(a) $CO_2$, $HC\ell$, $H_2$
(b) $CO_2$, $NaC\ell$, $H_2O$
(c) $CH_4$, $HC\ell$, $H_2O$
(d) C, $HC\ell$, $CH_2Br_2$

14. Which of the following has the molecules in order of **decreasing** bond polarity?

(a) $HC\ell$, HF, $CH_4$, $H_2$
(b) $H_2$, $CH_4$, $HC\ell$, HF
(c) $CH_4$, $H_2$, $HC\ell$, HF
(d) HF, $HC\ell$, $CH_4$, $H_2$

15. Which one of these is the **best** description of the crystal structure of vanadium chloride?

(a) A regular arrangement of positively charged vanadium atoms and negatively charged chlorine atoms in a crystalline lattice with electrostatic forces of attraction between oppositely charged atoms.
(b) Six vanadium ions surrounded by six chlorine ions in a crystalline lattice with electrostatic forces of attraction between oppositely charged ions.
(c) A regular arrangement of positively charged vanadium ions and negatively charged chloride ions in a crystalline lattice with electrostatic forces of attraction between oppositely charged ions.
(d) A three-dimensional structure of vanadium atoms and chlorine atoms with an electrostatic force of attraction between shared electrons and the nuclei of adjacent atoms.

16. Distillation is a separation technique that is useful when separating a mixture of liquids. Which of the following correctly identifies the physical property that enables the substances to be separated?

(a) Melting point
(b) Density
(c) Solubility in water
(d) Boiling point

17. Which of the following statements is the best description of the trends in the 1st ionisation energy of the elements on the Periodic Table?

(a) 1st ionisation energy increases across Period 3 and increases down groups of the Periodic Table.
(b) 1st ionisation energy decreases across Period 3 and decreases down groups of the Periodic Table.
(c) 1st ionisation energy increases across Period 3 and decreases down groups of the Periodic Table.
(d) 1st ionisation energy decreases across Period 3 and increases down groups of the Periodic Table.

18. Identify the all the types of bonding present in a solution of copper(II) chloride in ethanol.

I dispersion forces
II ion-dipole forces
III hydrogen bonds
IV ionic bonds

(a) II and IV
(b) I, III and IV
(c) I, II, and III
(d) All of the above.

19. Which of the following groups of solutions will produce a coloured precipitate when mixed?

All solutions are 0.1 mol $L^{-1}$.

| | | | |
|---|---|---|---|
| (a) | Copper(II) sulfate | Sodium chloride | Barium nitrate |
| (b) | Strontium bromide | Iron(III) nitrate | Sodium iodide |
| (c) | Potassium hydroxide | Copper(II) sulfate | Calcium bromide |
| (d) | Ammonium nitrate | Iron(II) chloride | Potassium sulfate |

20. Substance A is made up two components (O and P). A small sample of substance A was dotted onto chromatography paper, and a chromatogram was developed using an appropriate solvent. The result is shown below.


Compound P is adsorbed

(a) more strongly onto the stationary phase and has a smaller $R_f$ value than component O.
(b) more strongly onto the stationary phase and has a larger $R_f$ value than component O.
(c) less strongly onto the stationary phase and has a smaller $R_f$ value than component O.
(d) less strongly onto the stationary phase and has a larger $R_f$ value than component O.

**End of Section One**

**Section Two: Short answer** **34.4% (55 Marks)**

**Question 21** **(6 marks)**

(a) Write the formulae of each of the following compounds. (3 marks)

| Name | Formula |
|---|---|
| lithium carbonate | **$Li_2CO_3$** |
| chromium(III) bromide | **$CrBr_3$** |
| sulfur trioxide | **$SO_3$** |

| Description | Marks |
|---|---|
| Formula completely correct | 1 each |

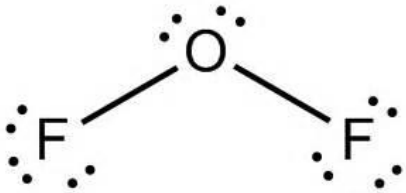
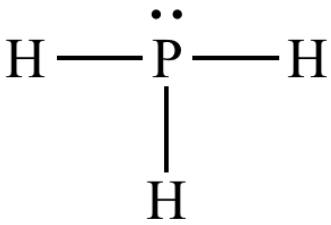
(b) Write the names of each of the following species. (3 marks)

| Formula | Name |
|---|---|
| $NH_4^+$ | **Ammonium** |
| $N_2O$ | **Dinitrogen monoxide** |
| $Fe(OH)_3$ | **Iron(III) hydroxide** |

| Description | Marks |
|---|---|
| Name completely correct | 1 each |

**Question 22** **(9 marks)**

Draw the Lewis structures for the following substances, showing all valence electrons. State whether each substance is polar or non-polar.

| Substance | Lewis Structure | Polarity |
|---|---|---|
| Hydrogen cyanide HCN |  **1 mark for bonds, 1 mark for lone pairs** | **Polar** **1 mark** |
| Oxygen difluoride $OF_2$ |  **1 mark for bonds, 1 mark for lone pairs** | **Polar** **1 mark** |
| Phosphine $PH_3$ |  **1 mark for bonds, 1 mark for lone pairs** | **Polar** **1 mark** |

| Description | Marks |
|---|---|
| Correct Lewis structure showing all bonding pairs and lone pairs | 2 per molecule |
| Lewis structure with correct bonding pairs but incorrect / missing lone pairs<br>OR<br>Lewis structure with incorrect bonding pairs, but lone pairs drawn correctly for the molecule drawn | 1 per molecule |
| Molecules described as polar | 1 per molecule |
| **TOTAL** | **9** |

**Notes:**

- **All electron pairs can be shown with either a line or two dots.**
- **Students may use one symbol for all electrons, or different symbols for electrons from different atoms.**

**Question 23** **(6 marks)**

For each of the following combinations, use your understanding of intermolecular forces to predict and explain whether the substances will form a solution.

(a) Methanol, $CH_3OH$, and water, $H_2O$. (3 marks)

| **Description** | **Marks** |
|---|---|
| Substances mix / miscible / form a solution | 1 |
| Both substances can form <u>hydrogen bonds</u> | 1 |
| Indication that substances can form intermolecular forces with each other | 1 |

(b) Hexane, $C_6H_{14}$, and decane, $C_{10}H_{22}$. (3 marks)

| **Description** | **Marks** |
|---|---|
| Substances mix / miscible / form a solution | 1 |
| Both substances can form <u>dispersion forces</u> | 1 |
| Indication that substances can form intermolecular forces with each other | 1 |

**Question 24** **(4 marks)**

Using a labelled diagram, show how ion-dipole forces are formed when sodium chloride dissolves in water.

| **Description** | **Marks** |
|---|---|
| Diagram includes both $Na^+$ ions and $Cl^-$ ions, and several $H_2O$ molecules per ion (sphere of hydration) | 1 |
| Water molecular aligned the right way round on each ion:<br>Oxygen pointing in towards $Na^+$ ion<br>Hydrogens pointing in towards $Cl^-$ ion | 1 |
| Polarity of water molecules indicated as partial charges | 1 |
| Ion-dipole bonds drawn and labelled (lines, dashed lines, dots, etc) | 1 |

**Question 25** **(9 marks)**

A sample of strontium was analysed in order to establish its relative atomic mass.

(a) What analytical technique was used to produce the data below? (1 mark)

| Description | Marks |
|---|---|
| Mass spectrometry (any reasonable spelling) | 1 |

| Isotope of strontium | Relative intensity |
|---|---|
| Strontium-84 | 0.6782 |
| Strontium-86 | 11.94 |
| Strontium-87 | 8.477 |
| Strontium-88 | 100.0 |

(b) Use the information in the table above to calculate the approximate percentage abundance of each isotope of strontium. (4 marks)

**$^{84}$Sr 0.56%** **$^{86}$Sr 9.86%** **$^{87}$Sr 7.00%** **$^{88}$Sr 82.58%**

| Description | Marks |
|---|---|
| Relative intensity values added to give total = 121.0952 | 1 |
| All four percentage abundance values correct | 3 |
| Three percentage abundance values correct | 2 |
| Two percentage abundance values correct | 1 |

**Note:**

- **If total intensity is incorrect, award error carried forward marks, maximum 3**

(c) Calculate the relative atomic mass of strontium. (2 marks)

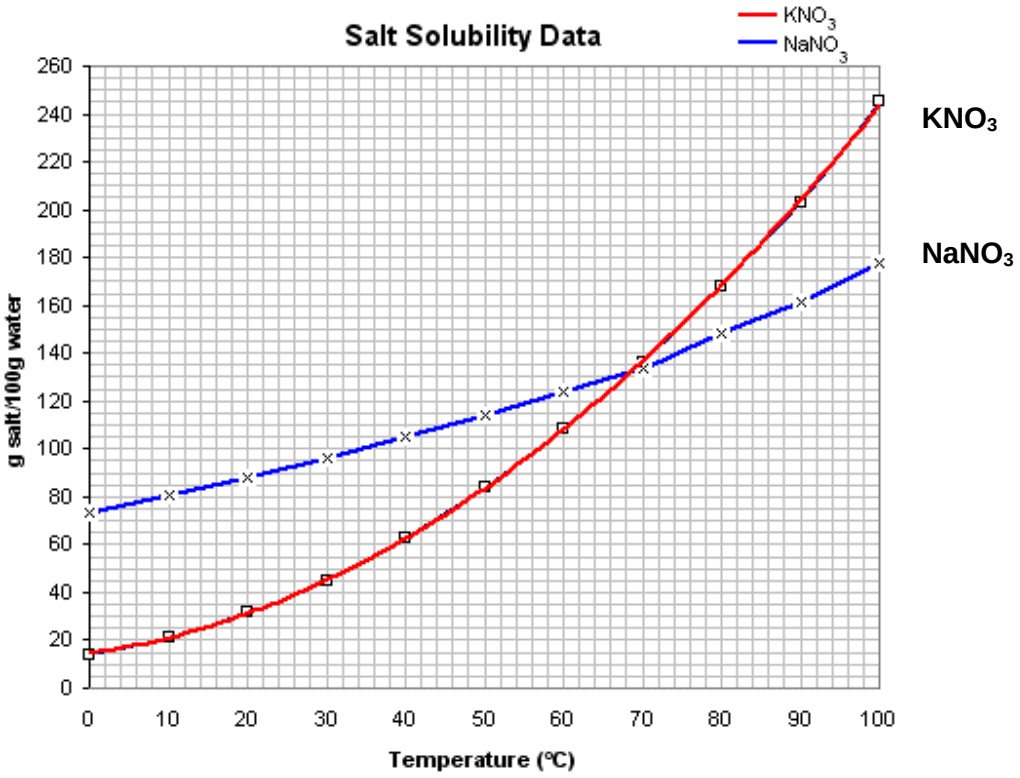
**$A_r$ = 87.71**

| Description | Marks |
|---|---|
| Sufficient working shown | 1 |
| Correct answer to at least 3 significant figures (no penalty for extra sig figs) | 1 |

(d) Describe two ways in which the isotopes of strontium are different. (2 marks)

| **Description** | **Marks** |
|---|---|
| Describe any two of the following:<br>• Different mass number<br>• Different number of neutrons<br>• Different density<br>• Different melting point or boiling point<br>• Different half-life / radioactive properties<br>• Any other physical property that differs between isotopes | 2 |

**Question 26** **(5 marks)**




**$KNO_3$**

**$NaNO_3$**

(a) Use the graph above to estimate the solubility of: (2 marks)

(i) Potassium nitrate at 40 °C.

**Any value in range 60 to 65 g / 100g**
**(1 square = 5 g / 100 g)**

(ii) Sodium nitrate at 85 °C.

**Any value in range 155 to 160 g / 100g**

| **Description** | **Marks** |
|---|---|
| Value within range specified, with units g / 100 g | 1 each |
| Both values within range, but units missing for one or both | 1 in total |

(b) If a solution of potassium nitrate is described as 5.5 g $L^{-1}$, calculate the concentration in mol $L^{-1}$. (1 mark)

**0.0544 mol $L^{-1}$**

| **Description** | **Marks** |
|---|---|
| Correct value given to at least 2 sig figs, with units | 1 |
| Value has fewer than 2 sig figs, or no unit | 0 |

(c) Explain the difference between the terms saturated and unsaturated, with reference to the data for a solution of sodium nitrate at 30 $^{o}$C. (2 marks)

- **Saturated – maximum amount of substance dissolved, for $NaNO_3$ 95-100 g/100g**
- **Unsaturated – less than max amount dissolved, for $NaNO_3$ anything less than amount stated above.**

| **Description** | **Marks** |
|---|---|
| Describes the meaning of saturated **and** unsaturated with reference to sodium nitrate, with accurate values used. | 2 |
| Describes the meaning of saturated **and** unsaturated, with **no** reference / inaccurate reference to sodium nitrate. | 1 |
| Describes the meaning of **either** saturated **or** unsaturated with reference to sodium nitrate | 1 |

**Note:**

- **Must have both saturated and unsaturated correctly described.**

**Question 27** **(5 marks)**

Consider the information about some pure substances.

| Substance | Melting point (°C) | Boiling point (°C) | Electrical conductivity in solid state | Electrical conductivity in liquid state | Solubility in water |
|---|---|---|---|---|---|
| 1 | 1535 | 2750 | good | good | insoluble |
| 2 | 800 | 1410 | non | good | soluble |
| 3 | -259 | -253 | non | non | insoluble |
| 4 | 1710 | 2590 | non | non | insoluble |
| 5 | 50 | 265 | non | non | insoluble |

(a) Which **one** of the substances above is most likely a **gas** at room temperature? (1 mark)

**3**

(b) Which **one** of the substances above is most likely to be a **covalent molecular solid**? (1 mark)

**5**

(c) Which **one** of the substances above is most likely to be a **metal**? (1 mark)

**1**

(d) Which **one** of the substances above is most likely a **covalent network** substance? (1 mark)

**4**

(e) Which **one** of the substances above is most likely an **ionic** substance? (1 mark)

**2**

| **Description** | **Marks** |
|---|---|
| Correct numbered substance | 1 each |
| Incorrect numbered substance or named substance | 0 |

**Question 28** **(6 marks)**

Write ionic equations **including state symbols** the following equations, and describe the observations you would expect to see for each reaction.

(a) Barium nitrate solution is mixed with iron(II) sulfate solution.

Ionic Equation: **$Ba^{2+}$ (aq) + $SO_4^{2-}$ (aq) → $BaSO_4$ (s)** (2 marks)

Observations: (1 mark)

**Clear colourless solution and <u>clear pale green solution</u> are mixed, forms a <u>white precipitate</u> and the solution becomes paler green in colour**

| **Description** | **Marks** |
|---|---|
| Correct ionic equation, with correct state symbols | 2 |
| Correct molecular equation, with correct state symbols<br>OR<br>Incorrect ionic equation with correct state symbols<br>OR<br>Correct ionic equation with incorrect state symbols | 1 |
| Correct molecular equation with incorrect state symbols<br>OR<br>Incorrect molecular equation with correct state symbols | 0 |
| Observation describes at least the formation of a white precipitate **and** the green solution decolourising / getting paler | 1 |

(b) Lead(II) nitrate solution is mixed with magnesium iodide solution.

Ionic Equation: **$Pb^{2+}$ (aq) + 2 $I^-$ (aq) → $PbI_2$ (s)** (2 marks)

Observations: (1 mark)

**2 clear colourless solutions form a <u>yellow precipitate</u> in a clear colourless solution**

| **Description** | **Marks** |
|---|---|
| Correct ionic equation, with correct state symbols | 2 |
| Correct molecular equation, with correct state symbols<br>OR<br>Incorrect ionic equation with correct state symbols<br>OR<br>Correct ionic equation with incorrect state symbols | 1 |
| Correct molecular equation with incorrect state symbols<br>OR<br>Incorrect molecular equation with correct state symbols | 0 |
| Observation describes at least the formation of a yellow precipitate | 1 |

**Question 29** **(5 marks)**

A student performed an investigation to establish the empirical formula of hydrated aluminium sulfate. A sample of hydrated aluminium sulfate was heated strongly until it reached a constant mass.

Using the data provided, calculate the empirical formula of hydrated aluminium sulfate.

| | |
|---|---|
| Mass of aluminium sulfate before heating | 17.561 g |
| Mass of aluminium sulfate after heating | 9.017 g |

| **Description** | **Marks** |
|---|---|
| Mass of water correctly calculated<br>**Mass of water = 17.561 – 9.017 = 8.544 g** | 1 |
| Moles of anhydrous $Al_2(SO_4)_3$ correctly calculated<br>**Moles anhydrous $Al_2(SO_4)_3$ = 9.017 / 342.17 = 0.02635 mol** | 1 |
| Moles of water correctly calculated<br>**Moles water = 8.544 / 18.016 = 0.4743 mol** | 1 |
| Mole ratio correctly calculated<br>**Mole ratio = 0.4743 / 0.02635 = 18** | 1 |
| Formula correctly written<br>**Formula = $Al_2(SO_4)_3.18H_2O$** | 1 |
| **TOTAL** | **5** |

**Notes:**

- **Errors carried forward receive credit for the step, providing working shown clearly, and calculation can be recreated from what is written on the page.**
- **Answers to steps do not need units for the mark**

**End of Section Two**

**Section Three: Extended answer** **40.6% (65 Marks)**

This section contains **4** questions. You must answer **all** questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

---

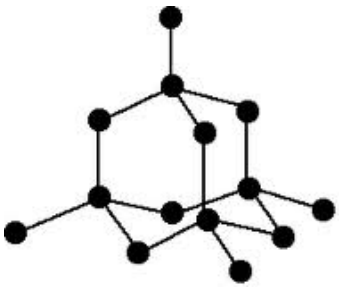
**Question 30** **(18 marks)**

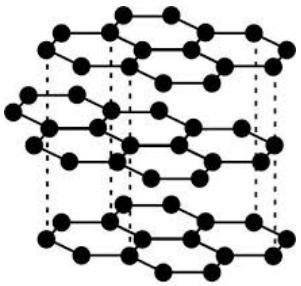
Diamond and graphite are two allotropes of carbon with distinctly different covalent network structures and physical properties. Compare them in terms of the following points.

(a) Compare the covalent network structures of both diamond and graphite, using a diagram if you wish. (4 marks)

**Diagrams not required, points can be covered with descriptions or labelled diagrams.**

**Diagrams might look a little like these, but as long as the 3D arrangement is clear, can receive some credit.**





| **Description** | **Marks** |
|---|---|
| Diamond has each carbon atom covalently bonded to 4 others | 1 |
| Diamond structure is tetrahedral throughout | 1 |
| Graphite has each carbon atom covalently bonded to 3 others in layers | 1 |
| Graphite layers have carbon atoms with a hexagonal arrangement, and delocalised electrons present | 1 |

(b) Electrical conductivity.

(i) Explain why diamond does not conduct electricity. (2 marks)

| **Description** | **Marks** |
|---|---|
| All electrons held in covalent bonds | 1 |
| No charged particles free to **flow / move** to carry current | 1 |

(ii) Explain why graphite does conduct electricity. (2 marks)

| **Description** | **Marks** |
|---|---|
| Each carbon atom has one delocalised electron | 1 |
| Delocalised electrons can **flow / move** to carry current | 1 |

(c) Hardness of the solid.

(i) Explain why diamond is so hard. (2 marks)

| **Description** | **Marks** |
|---|---|
| All carbon atoms bonded together with **strong** covalent bonds | 1 |
| 3D / tetrahedral lattice is rigid / hold atoms in place so diamond is hard | 1 |

(ii) Explain why graphite is soft. (2 marks)

| **Description** | **Marks** |
|---|---|
| Layers of atoms only held together by weak forces of attraction | 1 |
| Layers can slide over each other so graphite is soft | 1 |

(d) One emerging use of carbon is in nanomaterials. How is the structure of carbon nanomaterials different from either structure in part (a)? (3 marks)

| **Description** | **Marks** |
|---|---|
| Nanomaterials have smaller particles (in range 1-100 nm), compared to extended network of bonding in diamond / graphite | 1 |
| Carbon nanomaterials come in range of shapes eg: fullerenes are ball shaped, carbon nanotubes are tube shaped | 1 |
| Carbon nanomaterials have atoms bonded in (5 or 6 membered) rings | 1 |

(e) Briefly describe one advantage of using titanium dioxide nanomaterial in sunscreens. (1 mark)

| **Description** | **Marks** |
|---|---|
| Smaller $TiO_2$ particles are invisible on skin / no white residue seen / etc | 1 |

(f) List two possible health and safety concerns associated with the use of nanomaterials, such as titanium dioxide in sunscreen. (2 marks)

| **Description** | **Marks** |
|---|---|
| Any two from:<br>• Particles small enough to penetrate into body / organs<br>• Long term effect on body unknown – no long term studies done<br>• Nanoparticles are more reactive than larger particles so could react in an unexpected way<br>• Any other reasonable argument | 2 |

**Question 31** **(17 marks)**

(a) What was Niels Bohr's contribution to the understanding of atomic structure? (2 marks)

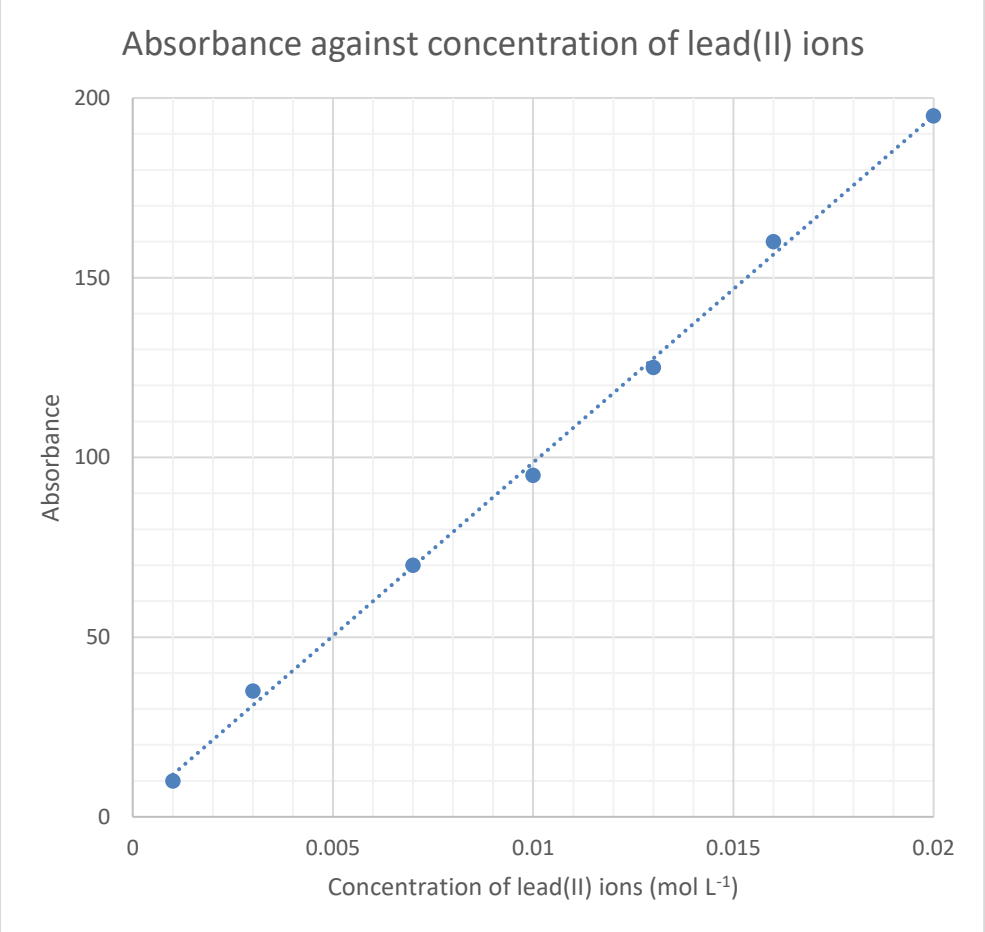
| Description | Marks |
|---|---|
| Any two from:<br>• Only certain energies allowed for each electron<br>• Electrons only found at certain distances / radii<br>• Lowest orbit has lowest energy<br>• Electrons can orbit without losing energy<br>• When electrons drop from higher energy levels to lower energy levels, they emit energy / light / photons<br>• To promote electrons from lower energy levels to higher energy levels, they absorb energy / light / photons | 2 |

(b) How does his contribution contribute to our understanding of analytical techniques such as Flame tests? (3 marks)

| Description | Marks |
|---|---|
| Electrons are excited from lower energy level to higher energy level by heat energy from flame | 1 |
| Electrons drop back from excited state to ground state and **emit** energy / light / photons | 1 |
| Light emitted has characteristic frequencies / wavelength / energy / spectrum / colour, enabling identification of element in flame | 1 |

(c) A drinking water sample was thought to be contaminated with lead(II) ions. The absorbance readings, on an Atomic Absorption Spectrometer, of some **known** samples of lead(II) ions are shown below. Draw a **graph** showing the relationship between lead(II) ion concentration and the absorbance level. (5 marks)

| Concentration of lead(II) ions (mg $L^{-1}$) | Absorbance |
|---|---|
| 0.0010 | 10 |
| 0.0030 | 35 |
| 0.0070 | 70 |
| 0.010 | 95 |
| 0.013 | 125 |
| 0.016 | 160 |
| 0.020 | 195 |




| Description | Marks |
|---|---|
| Horizontal axis (concentration of lead(II) ions) has label, units, even scale with numbers shown<br>AND<br>Vertical axis (absorbance) has label, even scale, number shown | 2 |
| Both axes have some of the above information, but not all parts | 1 |
| Axes wrong way round but otherwise correct | 1 |
| Axes have some information missing AND wrong way round | 0 |
| Graph has a useful title, eg: Absorbance against conc of lead(II) ions | 1 |
| Points plotted accurately | 1 |
| **Straight line of best fit** drawn with a ruler, as close as possible to points | 1 |
| **TOTAL** | **5** |

**Notes:**

- **If points incorrectly plotted and don't make a straight line, credit can be given for any good line of best fit drawn through the data, as long as it is either one straight line or a smooth curve with no kinks. No credit for dot to dot.**

(d) The suspect drinking water sample was then tested on the same Atomic Absorption Spectrometer and the absorbance measured at 105. Find the concentration of lead(II) ions, and use this to determine if the water is safe to drink. Briefly show your reasoning on the graph itself or in the space below.
(The maximum acceptable level of lead in drinking water has been established by the National Health and Medical Research Centre at 0.01 mg $L^{-1}$) (2 marks)

| **Description** | **Marks** |
|---|---|
| Working shown on graph with at least a horizontal line drawn from Abs = 105 to line of best fit, and a vertical line drawn from intersection of horizontal line and line of best fit, to the concentration axis.<br>OR<br>Working shown in mathematically, using equation for their line of best fit drawn (eg: y = mx + c, with values for m and c from their line of best fit) | 1 |
| Concentration of lead(II) ions in range 0.01 to 0.011<br>AND<br>Water not safe to drink | 1 |

**Note:**

- **If line of best fit is inaccurate, students can get full credit in this question if they show proper working, and give the correct conc of lead(II) for their graph, with the correct conclusion made.**

(e) An alternative way to monitor the concentration of contaminants in drinking water is using a precipitation reaction. Barium ions are harmful to health, and the National Health and Medical Research Centre state that they should not be present at a concentration greater than 2 parts per million. A sample of drinking water can be tested for barium ions by adding potassium sulfate solution.

Write an ionic equation for the precipitation reaction that takes place. (1 mark)

$$\mathbf{Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4}$$

| **Description** | **Marks** |
|---|---|
| Correct ionic equation, state symbols not required | 1 |
| Molecular equation | 0 |

(f) A 2.00 kg sample of drinking water is tested for barium ions by the addition of 100 mL of 1.00 mol $L^{-1}$ potassium sulfate solution. The mixture is stirred until no more precipitate forms, and the water is evaporated, until only a white solid remains. The mass of solid produced is 5.73 mg.

Assuming all of the white solid is barium sulfate, calculate the concentration of barium in the water sample in parts per million, and determine whether the barium level poses a risk to health. (4 marks)

| **Description** | **Marks** |
|---|---|
| Moles $BaSO_4$ correctly calculated<br>**Mol $BaSO_4$ = 5.73 x $10^{-3}$ / 233.37 = 2.455 x $10^{-5}$ mol** | 1 |
| Mass Ba correctly calculated<br>**Moles Ba = 2.455 x $10^{-5}$ mol**<br>**Mass Ba = 2.455 x $10^{-5}$ mol x 137.3 = 3.371 x $10^{-3}$ g ( = 3.371 mg)** | 1 |
| Conc Ba in ppm correctly calculated to 3sig figs<br>**Conc Ba = mass of Ba / mass of sample**<br>**= (3.371 x $10^{-3}$) x $10^{6}$ / 2000**<br>**= 1.6856 ppm**<br>**= 1.69 ppm (3sf)** | 1 |
| Correct conclusion drawn<br>**Water is safe to drink** | 1 |

**Notes:**

- **Errors carried forward receive credit for the step, providing working shown clearly, and calculation can be recreated from what is written on the page.**
- **Answers to steps 1 & 2 do not need units for the mark, but units need to be correct for step 3**

**Question 32** **(12 marks)**

The structure of the Periodic Table is based on the atomic number of the elements.

Refer to the properties of the elements in Period 2 to answer the following questions.

| Element | Atomic radius (pm) | Electronegativity |
|---|---|---|
| Li | 167 | 1.0 |
| Be | 112 | 1.6 |
| B | 87 | 2.0 |
| C | 67 | 2.6 |
| N | 56 | 3.0 |
| O | 48 | 3.4 |
| F | 42 | 4.0 |
| Ne | 38 | - |

.

(a) Describe and explain the trend in atomic radius across Period 2.

(3 marks)

| **Description** | **Marks** |
|---|---|
| From left to right across period 2, atomic radius decreases | 1 |
| All atoms in period 2 have the same number of valence shells / electrons are added to the same shell / second shell / etc | 1 |
| Increasing nuclear charge attracts valence shell with greater force (or words to that effect). | 1 |

(b) Describe and explain the trend in electronegativity across Period 2. (3 marks)

| **Description** | **Marks** |
|---|---|
| From left to right across period 2, electronegativity increases | 1 |
| All bonding electrons are from the same valence shell / second shell / etc | 1 |
| Increasing nuclear charge attracts bonding electrons with greater force so pulls electrons to a greater extent | 1 |

Sodium and chlorine are reactive elements with distinctly different physical and chemical properties. The chemically stable compound formed from these two elements has completely different properties to either element. The reactivity or stability of these three substances is related to their valence electrons.

(c) Explain these statements, **in terms of their position on the periodic table**, by completing the following table. (6 marks)

| **Statement** | **Possible Student Response (Guidance only)** | **Marks** |
|---|---|---|
| Sodium readily forms ions | • **Sodium is in group 1, so has a low (first) ionisation energy, so it's one valence electron is lost easily.**<br>• **The $Na^+$ ion formed is stable due to its full valence shell configuration.** | 2 |
| Chlorine readily forms ions | • **Chlorine is in group 17, so has a high electron affinity / gains an electron readily.**<br>• **The $Cl^-$ ion formed is stable due to the full valence shell configuration.** | 2 |
| The chemically stable compound formed from these elements has completely different properties to either element | • **NaCl formed from $Na^+$ and $Cl^-$ ions which are both stable.**<br>• **Ionic compound has different properties from either element, as the substance has significantly different bonding.** | 2 |

| **Description** | **Marks** |
|---|---|
| Explanations link group and number of valence electrons, to the ease of forming ions for both Na & Cl. | 2 |
| Explanations link stability of ions formed to having full valence shell configurations for $Na^+$ and $Cl^-$. | 2 |
| Explanations show understanding that the stability and properties of the compound formed are different due to the bonding being different. | 2 |
| **TOTAL** | **6** |

**Notes:**

- **Marks can be awarded for ideas even if the information is written in a different box in the grid.**
- **Credit should be awarded for arguments that use scientific terminology accurately, but should not be awarded for vague statements.**
- **Students should make six distinct points for full marks.**

**Question 33** **(8 marks)**

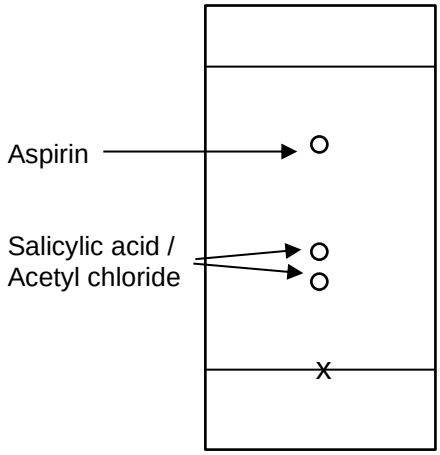
(a) Using a diagram, describe what you would expect to see on the chromatogram if the student's aspirin mixture was contaminated with both reagents. You should indicate the relative positions of the substances aspirin, salicylic acid and acyl chloride on the plate.

(3 marks)

**Diagram might be similar to the one below.**

**Important features of a diagram:**

- **Aspirin dot travels furthest**
- **Two other dots drawn for the two reagents**
- **Solvent front, baseline and cross drawn.**




| Description | Marks |
|---|---|
| Baseline and solvent front drawn on a rectangular plate | 1 |
| Aspirin appears higher on the plate than reagents | 1 |
| Reagents shown with two distinct spots, below the spot for aspirin. | 1 |

**Note:**

- **Spots must be labelled, any clear system accepted.**

(b) Explain why thin layer chromatography can be used to separate a mixture of aspirin and the reagents used to produce it, using your understanding of the polarity of substances present.

(5 marks)

| **Description** | **Marks** |
|---|---|
| Methodology relies on differing solubility / affinity for mobile phase **and** stationary phase for **each** substance in order to separate. | 1 |
| Silica (stationary phase) is very polar so the more polar reagents adsorb strongly. | 1 |
| Reagents are not very soluble in the non-polar solvent, so are not carried very far up the plate. | 1 |
| Aspirin is not very polar so forms weaker bonds than reagents with the very polar stationary phase. | 1 |
| Aspirin is more soluble in the non-polar mobile phase so is carried further up the plate. | 1 |
| **TOTAL** | **5** |

**End of questions**