Student Number.........................

Theory Mark ....

Data Processing Mark.................

James Ruse Agricultural High School

Theory and Data Processing

Chemistry Assessment
Task 1 Term 4 2010

General Instructions

- **Reading Time**:   5 minutes
- **Working Time**:   90 minutes
- **Complete both Theory and Data Processing in the time, 90 minutes.**
- Write using black or blue pen
- Board approved calculators may be used
- Write your Student Number at the top of this page
- A Periodic Table and Data Sheet are attached to the back of the paper

Total Marks   59

Theory Test
Total marks 29
Take about 40 minutes
to do this section

Data Processing
Total marks 32
Take about 50 minutes
to do this section

Part A

Multiple Choice: 5 marks
Attempt Questions 1-5

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 =   (A) 2   (B) 6   (C) 8   (D) 9

A ◯   B ●   C ◯   D ◯

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ●   B ✖   C ◯   D ◯

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word *correct* and drawing an arrow as follows.

correct

A ✖   B ✖   C ◯   D ◯

‣ **Mark your answers for Questions 1 – 5 in the Answer Box on page 8**

Theory Paper - 29 marks

1. Which of the following correctly matches the common name of the monomer with the systematic name of the polymer? (discarded)

	Common Name	Systematic Name
(A)	styrene	polystyrene
(B)	vinyl chloride	chloro ethane
(C)	ethylene	ethene
(D)	glucose	cellulose

2. Which term best describes the relationship between the compounds shown below?
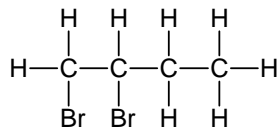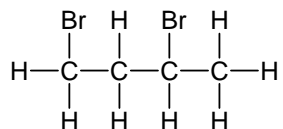
(A) allotropes

(B) isomers

(C) isotopes

(D) monomers

3. What is the main industrial source of ethene?

(A) cellulose

(B) glucose

(C) ethanol

(D) petroleum

4.   What is the IUPAC name for the following compound?
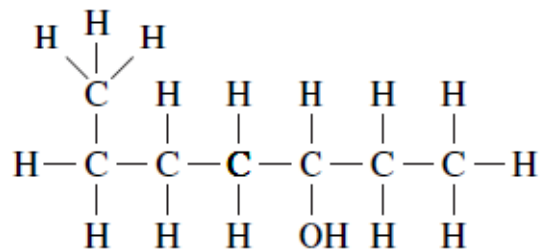
(A)   3 – heptanol

(B)   5 – heptanol

(C)   3 – hexanol

(D)   4 – hexanol

5.   In a fermentation experiment, 8.5 g of glucose was completely converted to ethanol and carbon dioxide.

        What is the volume of carbon dioxide produced at 25^0C ?

(A)   0.047 L

(B)   1.17 L

(C)   2.14 L

(D)   2.34 L

6.   Alpha particles flow through an evacuated tube and some observations were made. Which of the following would NOT be observed ?

(A)   Repulsion by a positive electrode.

(B)   Passage stopped by a piece of tissue paper.

(C)   A faint green glow on collision with the glass sides.

(D)   Attraction by a positive electrode.

Use this information to answer questions 7 and 8:
A group of students were asked to test the reactivity of several elements and their corresponding ions in aqueous solutions (1.0 mol L^{-1}) .
The students performed the test by adding each element to the solution of the ions of each of the elements. They also tested the reaction of the elements with dilute HCl.
The names of the ions are all fictitious except for hydrogen, H^+.

Element	Ions					
	A^{2+}	J^{2+}	M^{2+}	Q^{2+}	R^{2+}	H^+
A	NT	R++	R+	R+++	X	R+
J	X	NT	X	R+	X	X
M	X	R+	NT	R++	X	X
Q	X	X	X	NT	X	X
R	R+	R++++	R+++	R+++++	NT	R++

Legend: X = no visible result NT= not tested
R = reaction vigour indicated by the number of positive signs.

7.   Which of the following arranges some of the elements according to increasing reactivity?

(A)   M J Q

(B)   J R M

(C)   Q A R

(D)   A J M

8.   Which of the following arranges some of the ions according to increasing oxidizing ability?

(A) R^{2+} M^{2+} J^{2+}

(B) Q^{2+} A^{2+} R^{2+}

(C) Q^{2+} J^{2+} M^{2+}

(D) R^{2+} Q^{2+} M^{2+}

9.   Which of the following pairs of atoms have the same number of neutrons ?

(A)   O – 16 and K – 39

(B)   Mg – 24 and Ne – 20

(C)   Al – 27 and N – 14

(D)   Cl – 35 and Ar – 36

Student Number...

Theory Mark ………………………….

Part A: Answer grid for multiple choice questions

1. A O B O C O D O

2. A O B O C O D O

3. A O B O C O D O

4. A O B O C O D O

5. A O B O C O D O

6. A O B O C O D O

7. A O B O C O D O

8. A O B O C O D O

9. A O B O C O D O

Part B : Extended Response Questions (20 Marks)

Question   10 (4 marks)

Discuss the need for alternative sources of the compounds presently obtained from the petrochemical industry.

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Year11 HSC Chemistry Theory and Data Processing Assessment Term 4 2010

Question 11 (2 marks)

Ethanol can be used as a solvent for many substances.

Account for the many uses of ethanol as a solvent.

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Question 12 (4 Marks)

You performed a first- hand investigation that determined the heat of combustion of ethanol.

(a)   Write a balanced equation for the reaction (1 mark)

………………………………………………………………………………………………………

(b)   The heat of combustion of ethanol is 1367 $kJmol^{-1}$. Calculate the mass of ethanol
        required to raise the temperature of 300 g of water by $10^{0}C$. (Assume all the heat
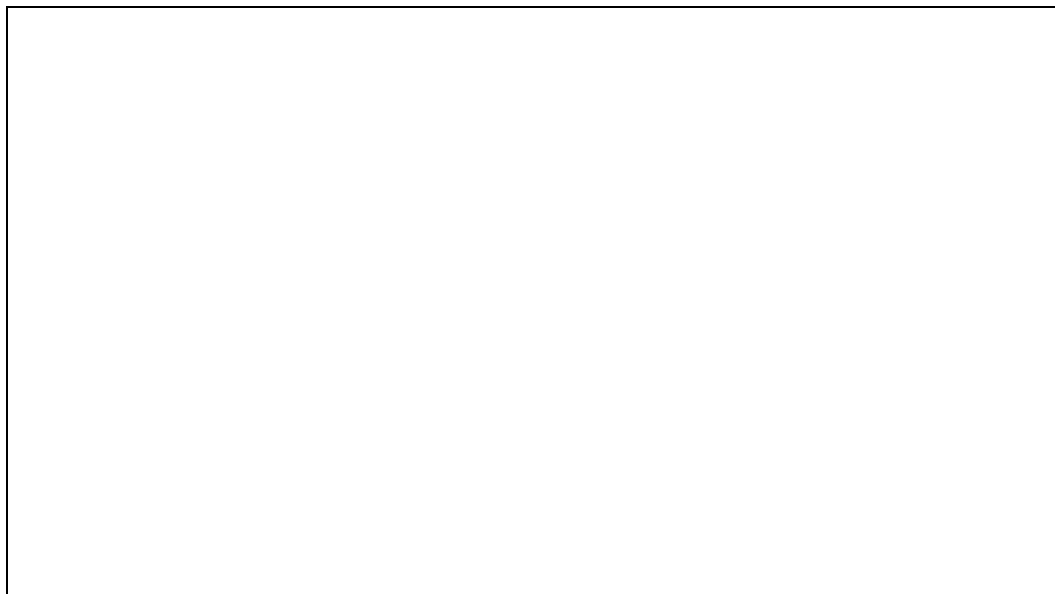   released is used to heat the water).(3 marks)

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Question 13 (6 marks)

(a)   Draw a neat, labelled diagram of a galvanic cell using silver and nickel, and
       soluble salts of these metals. (2 marks)

(b)   Clearly indicate in your diagram:

                (i)   the cathode of the cell.(1 mark)
                (ii)   the direction of the electron flow in the external circuit (1 mark)
                (iii)   the direction of anion flow from one half-cell to the other
                         half-cell (1 mark)

(c)   Calculate the standard cell potential of the galvanic cell. (1 mark)

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Year11 HSC Chemistry Theory and Data Processing Assessment Term 4 2010

Question 14 (4 marks)

Compare the chemistry of either a dry – cell battery or a lead – acid cell battery with one other cell (battery). Include relevant equations in your answer.

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End of Theory Test

Continue with Data Processing

Data Processing Mark ………………………….

Data Processing Paper - 29 marks

Use the information in the *Stimulus Booklet* to answer the following questions.

Question 1 (11 marks) Refer to **Stimulus A** and **Stimulus B**

Examine the following plot:.
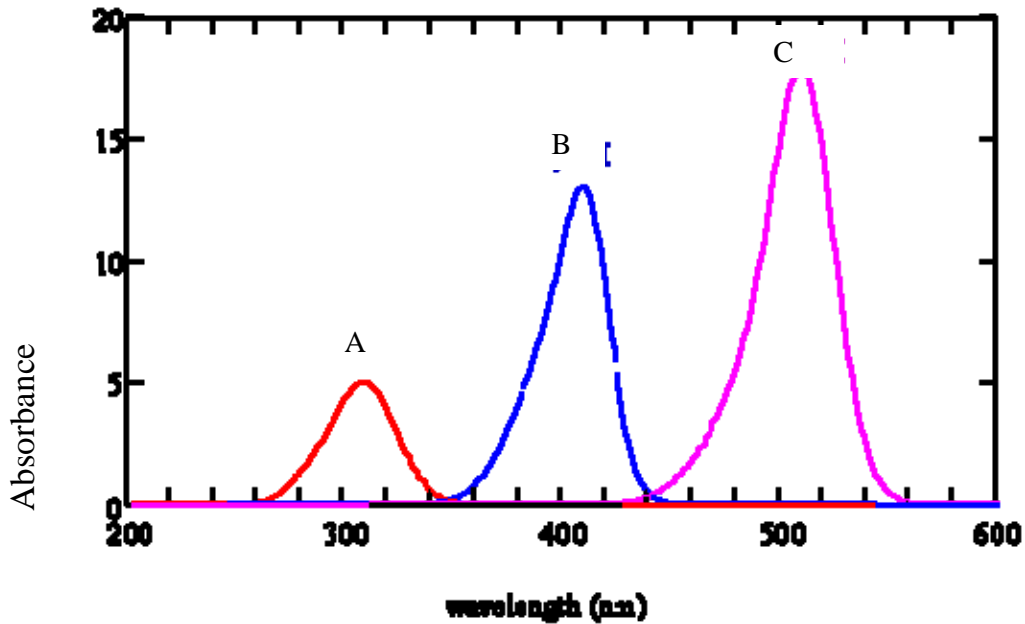
(a)   If substance C is to be measured colorimetrically in the presence of substances A and B, what wavelength should be used for analysis, so that A and B do not interfere?
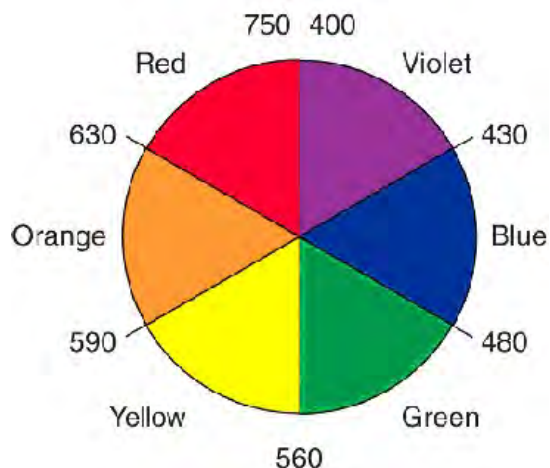
Justify your answer (2 marks)

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(b) (i) Using the colour wheel and the previous graph in part (a), determine the colour that C absorbs most? (1 mark)


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           750  400
    Red              Violet
630                         430

Orange                       Blue

590                          480
    Yellow           Green
           560
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………

(ii) If a substance absorbs one colour, then it will appear to our eyes as the complement of that colour it absorbs. For example, in the colour wheel above, the complement of orange is blue, so a blue solution is actually absorbing the orange component of visible light. What is the colour of C? (1 mark)

………

(c) What colour of filter should be used in the analysis of C to make the radiation *more monochromatic?*(1 mark)

………

(d) To analyse a substance colorimetrically, the following steps are followed:

(1) prepare a series of solutions with increasing concentrations of the substance

(2)   measure the absorbance for each concentration

(3) construct an absorbance – concentration graph

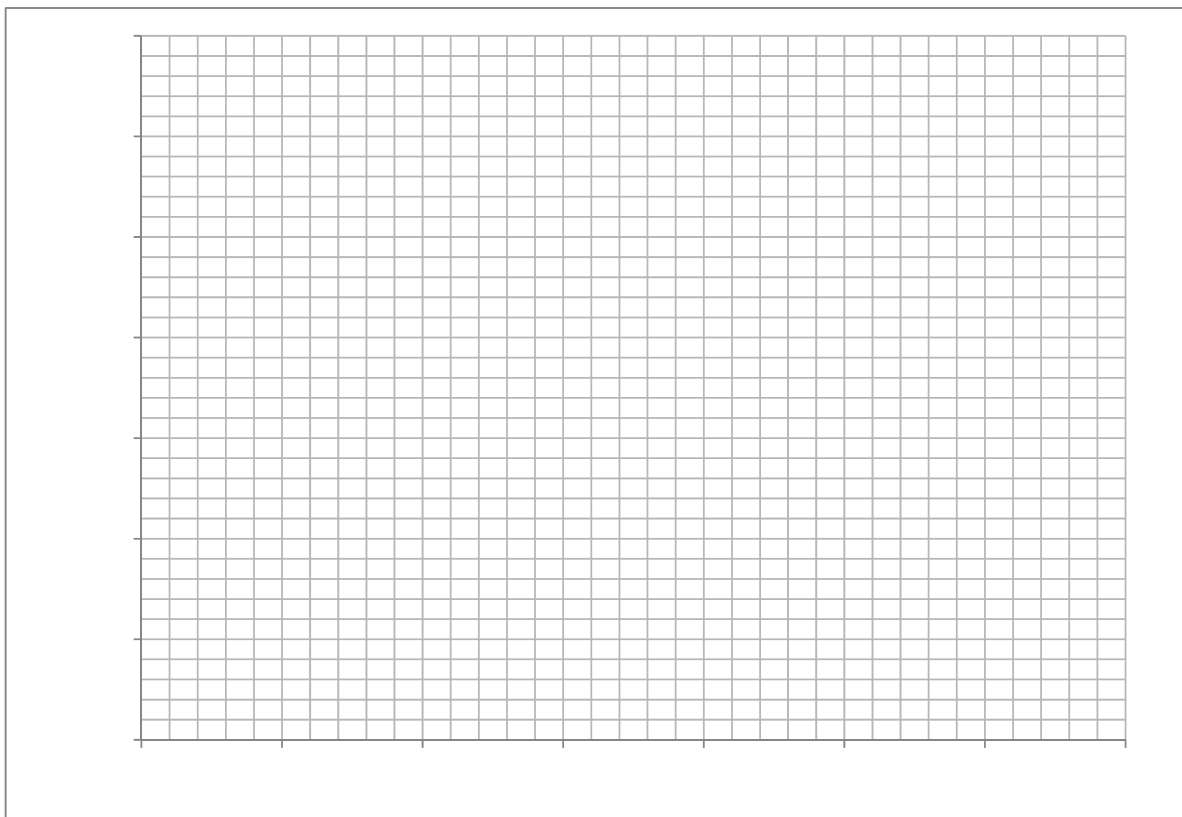(4)   determine the concentration of the same substance of unknown concentration graphically.

Use the procedure given in (3) and (4) to solve the following problem:

Stainless Steel is an alloy of iron and a variety of other elements.

A 1.000 g sample of steel was dissolved, by reaction, in nitric acid and the manganese in the sample was oxidized to permanganate with potassium periodate. The solution was diluted to 500.0 mL and gave an absorbance reading of 2.3 at 520 nm. Standard permanganate solutions gave the following readings:

Concentration (mol L^{-1})	Absorbance
0.0010	1.0
0.0020	2.0
0.0030	3.0

(i)   Draw a labeled absorbance – concentration graph. (2 marks)

Year11 HSC Chemistry Theory and Data Processing Assessment Term 4 2010

(ii)   Graphically determine the concentration of the unknown permanganate solution.
         (1 mark)

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(iii)   Calculate the percent manganese in the steel. (3 marks)

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Question 2 (7 marks) **Refer to Stimulus C**

(a)   Given the following half equations, determine the overall cell reaction.(1 mark)

$$H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$$

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

…………………………………………………………………………………………………
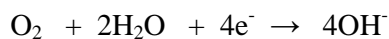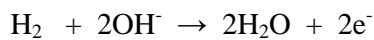
(b)   At which point A, B, or C is hydrogen passed into the cell ?

Explain your answer. (2marks)

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(c)   Why do you think the fuel cell is considered as an alternative energy source to the combustion of fossil fuels ? (2marks)

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(d)   Fuel cells are currently not used on a large scale. State two disadvantages of this cell.

(2 marks)

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Question 3 (4 marks)

Refer to *Figure 1* in the Stimulus Booklet to answer Question 3

(a)   Calculate the total mass of fermentable sugars obtained from the processing of 200 wet tons of sugar cane ("field cane"). (1 mark)

……………………………………………………………………………………………………

(b)   (i)   What type of sugar constitutes the bulk of fermentable sugars? (1 mark)

……………………………………………………………………………………………………

        (ii)   Calculate the % w/w of the sugar you gave in (a) for the fermentable sugars. (1 mark)

……………………………………………………………………………………………………

(c)   Determine the % conversion from fermentation to carbon dioxide and ethanol. (1 mark)

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Question 4 (4 marks)

Refer to *Figure 2* in the Stimulus Booklet to answer Question 4.

(a)   Identify which alternative fuel has the most impact on greenhouse gas emissions. Explain how you derived your answer. (2 marks)

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(b)   Describe two other features the data reveals about the use of alternative fuels. (2 marks)

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Year11 HSC Chemistry Theory and Data Processing Assessment Term 4 2010

Question 5 (3 marks)

Refer to *Figure 3* in the Stimulus Booklet to answer Question 5

(a) Which plastics should aromatic hydrocarbon solvents not be used on? (1 mark)

……………………………………………………………………………………………………

(b) State the name of a polymer that would be the most suitable for containing vegetable oil. (1 mark)

……………………………………………………………………………………………………

(c) Identify a polymer that could tolerate all of the following conditions.

120°C; can be sterilised using radiation or chemical means; clear; rigid; excellent resistance to mineral oils and dilute acids.(1 mark)

……………………………………………………………………………………………………

End of Data Processing Test

Year 11 term 4 Chemistry 2010 answers

Part A: Answer grid for multiple choice questions

1. ~~A 〇   B 〇   C 〇   D 〇~~

2. A 〇   **B√**   C 〇   D 〇

3. A 〇   B 〇   C 〇   **D √**

4. **A √**   B 〇   C 〇   D 〇

5. A 〇   B 〇   C 〇   **D √**

6. A 〇   B 〇   C 〇   **D √**

7. A 〇   B 〇   **C √**   D 〇

8. **A√**   B 〇   C 〇   D 〇

9. A 〇   B 〇   C 〇   **D√**

1. Which of the following correctly matches the common name of the monomer with the systematic name of the polymer? Discarded

	Common Name	Systematic Name
A	styrene	polystyrene
B	vinyl chloride	chloro ethane
C	**ethylene**	**ethene**
D	glucose	cellulose

Outcomes :H9

2. Which term beat describes the relationship between the compounds shown below?
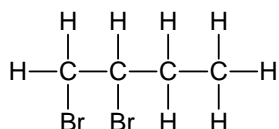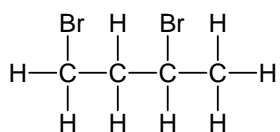
(A) allotropes

(B)   isomers

(C) isotopes

(D) monomers

Outcomes :H9

3. What is the main industrial source of ethene?

(A) cellulose

(B) glucose

(C) ethanol

(D)   petroleum

Outcomes :H4,H9

Year 11 HSC Chemistry Assessment 1 Term 4 2010 - Answers

4. What is the IUPAC name for the following compound?
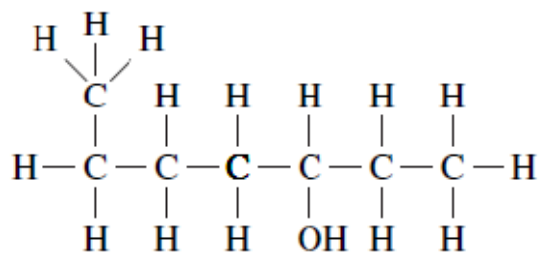
(A) **3 – heptanol**

(B) 5 – heptanol

(C) 3 – hexanol

(D) 4 – hexanol

Outcomes :H9

5. In a fermentation experiment, 8.5 g of glucose was completely converted to ethanol and carbon dioxide.

What is the volume of carbon dioxide produced at 25^0C ?

(A) 0.047 L

(B) 1.17 L

(C) 2.14 L

(D) **2.34 L**

Outcomes :H9,H10

6. Alpha particles flow through an evacuated tube and some observations were made..

Which of the following would NOT be observed ?

(A) Repulsion by a positive electrode.

(B) Passage stopped by a piece of tissue paper.

(C) A faint green glow on collision with the glass sides.

(D) **Attraction by a positive electrode.**

Outcomes: H2, H6

Use this information to answer questions 7 and 8:

A group of students were asked to test the reactivity of. several elements and their corresponding ions in aqueous solutions $(1.0\ mol\ L^{-1})$.

The students performed the test by adding each element to the solution of the ions of each of the elements. They also tested the reaction of the elements with dilute HCl.

The names of the ions are all fictitious except for hydrogen, H^+.

Element	Ions					
	A^{2+}	J^{2+}	M^{2+}	Q^{2+}	R^{2+}	H^+
A	NT	R++	R+	R+++	X	R+
J	X	NT	X	R+	X	X
M	X	R+	NT	R++	X	X
Q	X	X	X	NT	X	X
R	R+	R++++	R+++	R+++++	NT	R++

Legend: *X* = no visible result *NT*= not tested

   R = reaction vigour indicated by the number of positive signs.

7.   Which of the following arranges some of the elements according to increasing   reactivity?

(A)   M J Q

(B)   J R M

(C)   Q A R

(D)   A J M   **Outcomes:H14, H7**

8.   Which of the following arranges some of the ions according to increasing oxidizing ability?

(A) R^{2+} M^{2+} J^{2+}

(B) Q^{2+} A^{2+} R^{2+}

(C) Q^{2+} J^{2+} M^{2+}

(D) R^{2+} Q^{2+} M^{2+} **Outcomes:H14, H7**

9.   In which of the following pairs do the isotopes have atoms with the same number of neutrons ?

(A)   O – 16 and K – 39

(B)   Mg – 24 and Ne – 20

(C)   Al – 27 and N – 14

(D)   Cl – 35 and Ar – 36

Outcomes : H6, H10

Free response questions

Question 10 (4 marks)

Discuss the need for alternative sources of the compounds presently obtained from the petrochemical industry.

Sample Answer

Some compounds presently obtained from the petrochemical industry are plastics.

The feedstock for many plastics is ethene which is obtained from catalytic cracking of long chain alkanes, recovered in the fractional distillation of crude oil. Crude oil is a non renewable resource that will run out. For plastic production to continue alternative sources for ethene are necessary, from renewable resources. Cellulose, from biomass,can supply the raw materials to create ethene.

Cellulose → glucose →ethanol →ethene

ie cellulose is broken down to make glucose which can undergo fermentation to make ethanol which can be dehydrated to form ethene which can be used in the petrochemical industry.

Biopolymers from renewable resources can also be biodegradable which relieves the build up of rubbish.

Marking Criteria	Marks
• Discusses the need for alternative sources giving at least two reasons eg, non-renewable petroleum and non-biodegradable plastics	4
• Discusses the need for alternative sources citing only one reason	3
• Outlines the need for alternative sources	2
• Identifies a product of the petrochemical industry OR • States that crude oil/petroleum is non-renewable OR • Identifies an alternative source for ethene	1

Outcomes :H4,H5,H9

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-

- *Discuss the need for alternative sources of compounds presently obtained from the petrochemical industry.*

"Discuss" is defined by the BOS lexicon as ...

Identify issues and provide points for **(+)** *and/or against* **(–)**

Issues and Main Points with Keywords

- **The main compounds obtained from the petrochemical industry are fuels (95%) and ethene (<5%) via the processes of fractional distillation and catalytic cracking.**
- **These compounds and their end-products (fuels & plastics) are essential for the functioning of the economy and civilisation. (+)**
- **Petroleum and coal are non-renewable finite resources, hence alternatives must be found. (+)**
- **Alternative sources are found in biomass (carbohydrates and cellulose). Ethanol can be produced by fermentation and cellulosic production of ethanol is also possible. Subsequently, ethanol yields ethene by dehydration.**
- **Alternative non-hydrocarbon fuels (e.g. ethanol) can produce less CO_2 greenhouse emissions and pollution. (+)**
- **Some traditional plastics are recyclable, (e.g. PE, PET) but ultimately they end up as non-biodegradable waste in landfill. Biopolymers are alternative plastics sourced from biomass which have the added benefit of being biodegradable. (+)**
- **At the moment, production of alternative fuels and bio-polymers is less economic than petroleum-based production, but with the inexorable rise in the cost of oil, alternative production will become practicable. (–)**

Question 11 (2 marks)

Account for the many uses of ethanol as a solvent.

Sample answer

Ethanol has both polar and non-polar ends. The polar –OH end can hydrogen bond with water and dissolve polar substances and the non-polar hydrocarbon (-C_2H_5) end can form dispersion forces with other non polar substances. Thus ethanol can act as a solvent for both polar and non-polar substances allowing it to be used for many purposes.

Marking Criteria	Marks
• Accounts for the use of athanol as a solvent by identifying that the polar end dissolves polar substances and the non-polar end dissolves non-polar substances.	2
• Idenitifes the polar and non-polar nature of ethanol	1

Outcomes : H4,H6,H9

Question 12 (6 Marks)

You performed a first hand investigation that determined the heat of combustion of ethanol.

(a)   Outline the procedure you used. (2 marks)

Sample answer

An aluminium can was filled with 200ml of water and suspended over a spirit burner containing ethanol. The burner was weighed before and after burning to determine the mass of fuel burnt. The spirit burner was lit under the can and burnt for 10 minutes. The change in temperature of the water in the can was measured to determine the heat released.

Marking Criteria	Marks
• Outlined a valid procedure	2
• Identified two valid measurements taken OR • Identified correct equipment	1

(b)   Write a balanced equation for the reaction (1 mark)

CH_3CH_2OH (l)   + 3 O_2(g) → 2 CO_2 (g) + 3H_2O(l)
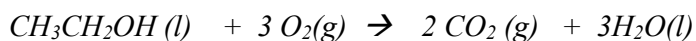
(c)   The heat of combustion of ethanol is 1367 kJmol^{-1}. Calculate the mass of ethanol required to raise the temperature of 300g of water by 10^{0}C. Assume all the heat released is used to heat the water.

    (3 marks)

Sample answer

$\Delta H \quad = \ -mc\Delta T$

$\qquad = \ - \ 300 \ x \ 4.18 \ x \ 10$

$\qquad = \ - \ 12540 \ J$

$\qquad = \ - \ 12.54 \ kJ$

Molar mass of C_2H_5OH $\qquad = \ 2x12 \ + \ 6x1 \ + \ 16$

$\qquad\qquad\qquad\qquad = \ 46g$

46g C_2H_5OH liberates 1367 kJ

xg C_2H_5OH liberates   12.54 kJ

x $\qquad = \ 12.54 \ x \ 46/1367$

$\qquad = \ 0.42 \ g$

Marking Criteria	Marks
• Correctly calculates the mass of ethanol with relevant working	3
• Calculates ΔH AND calculates molar mass of ethanol OR • Calculates mass of ethanol but fails to convert J to kJ OR • Correctly calculates the mass of ethanol without all relevant working	2
• Calculates ΔH OR • Calculates molar mass of ethanol	1

Outcomes :H7,H9,H10

Question 13 (6 marks)

(a)   Draw a neat, labelled diagram of a galvanic cell using silver and nickel, and soluble salts of these metals. (2 marks)
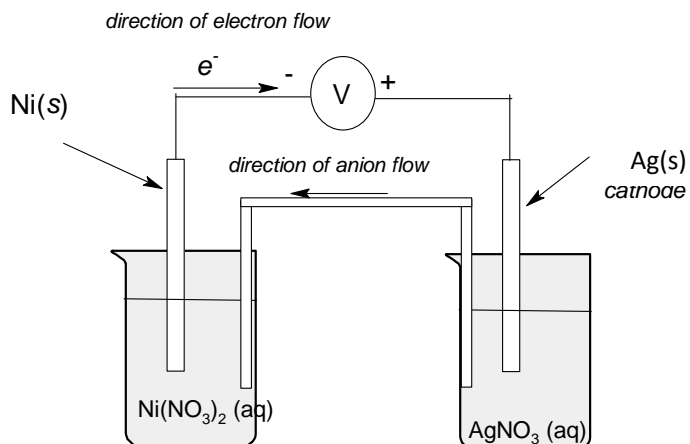
(b)   Clearly indicate in your diagram:

        (i)   the cathode of the cell.(1 mark)
        (ii)   the direction of the electron flow in the external circuit (1 mark)
        (iii)   the direction of anion flow from one half-cell to the other
          half-cell through the salt bridge (1 mark)

(c)   Calculate the standard cell potential of the galvanic cell. (1 mark)

Sample Answer: $E^o_{cell} = +0.80 - (- 0.23) = + 1.03 \ V$ *(1 mark)*

Criteria	Mark(s)
Neat diagram showing • two containers (beakers) with solutions • two electrodes dipping into the solution in each beaker • a salt bridge.	2
Neat diagram showing • two containers (beakers) with solutions • two electrodes (labelled) dipping into the solution in each beaker no salt bridge.	1
Parts other than the salt bridge missing	0

Criteria	Mark
Correct labels placed close to the part being labelled	1 mark for each correct label

Criteria	Mark
Correct calculation	1

Year 11 HSC Chemistry Assessment 1 Term 4 2010 - Answers

Question 14 (4 marks)

Compare the chemistry of either a dry – cell battery or a lead – acid cell battery with one other cell(battery). Include relevant equations in your answer. (4 marks)
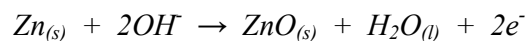
Sample Answer :

Dry Cell : Anode : zinc container $Zn \rightarrow Zn^{2+} + 2e^-$

Cathode : carbon graphite rod surrounded by a layer of ammonium chloride and manganese dioxide paste. The manganese ion is reduced
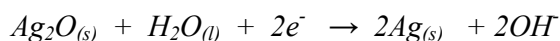
$Mn(IV) + e^- \rightarrow Mn(III)$
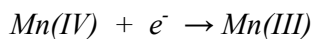
Electrolyte : paste containing ammonium chloride and zinc chloride

Button Cell : Anode : powdered zinc

$Zn_{(s)} + 2OH^- \rightarrow ZnO_{(s)} + H_2O_{(l)} + 2e^-$

Cathode : carbon and Ag_2O paste or lithium

$Ag_2O_{(s)} + H_2O_{(l)} + 2e^- \rightarrow 2Ag_{(s)} + 2OH^-$

*Electrolyte : potassium hydroxide*

Marking Guidelines

Marking Criteria	Marks
Complete correct chemistry including equations for the anode, cathode and electrolyte for both batteries ie either dry-cell or lead-acid cell compared to one other.	4
One of the above missing	3
Two of the above missing	2
Three of the above missing	1

Outcomes : H3, H4, H13

Data Processing

Question 1

Examine the following plot:.
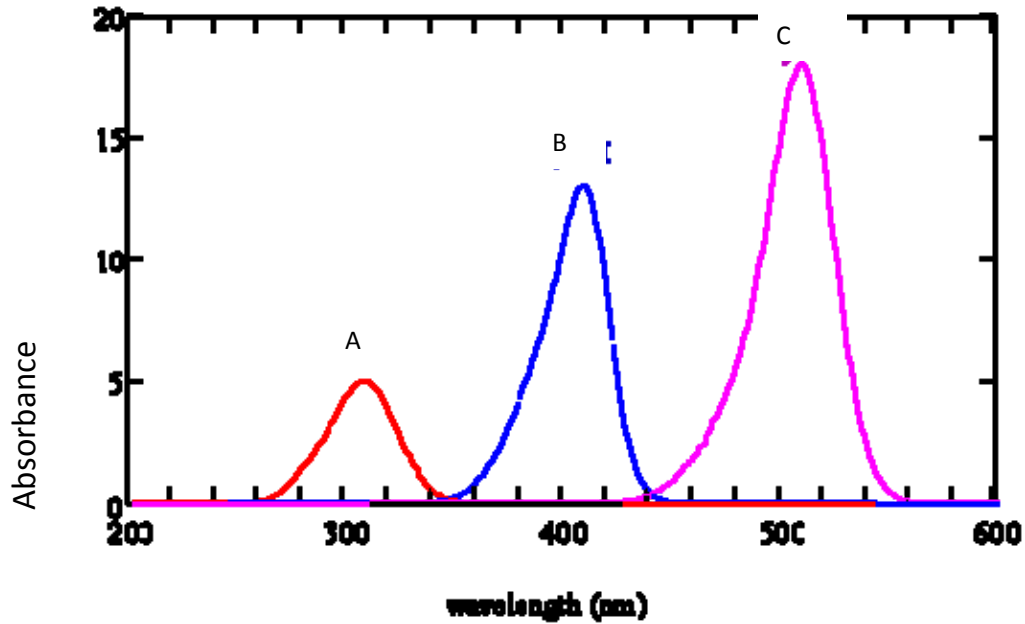
(a)   If substance C is to be measured colorimetrically in the presence of substances A and B, what wavelength should be used for analysis, so that A and B do not interfere?
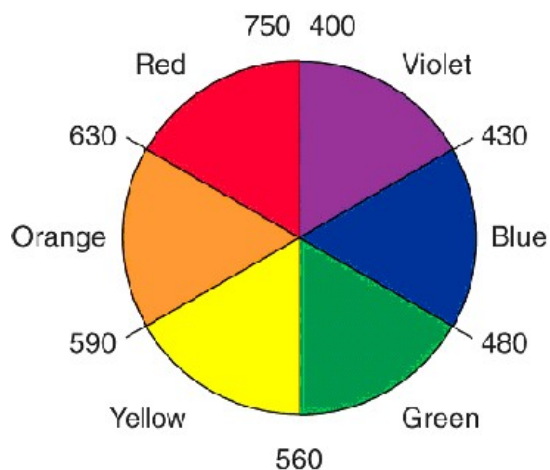
Justify your answer (2 marks)

Sample answer:

about 510 nm – the absorbance of C is maximum at this wavelength whereas A and B do not absorb at all

<table>
<tr><td rowspan="3">**Outcome(s): H11, H13**</td><td>*Criteria*</td><td>*Mark(s)*</td></tr>
<tr><td>correct wavelength</td><td>1</td></tr>
<tr><td>correct justification</td><td>1</td></tr>
</table>

(b).   (i)   Using the colour wheel and the previous graph in part (a), determine the
               colour that C absorbs most? (1mark)

Outcome(s):H13,H14

Sample answer

      C absorbs *green*

      The colour that corresponds to the wavelength absorbed most by C as read from the colour wheel

    Marking Guidelines

(ii)

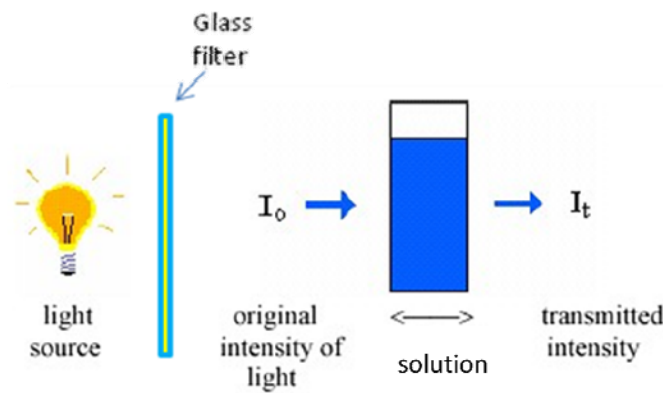| Criteria	Mark(s)
correct colour	1

If a substance absorbs one colour, then it will appear to our eyes as the complement of that colour it absorbs. For example, in the colour wheel above, the complement of orange is blue, so a blue solution is actually absorbing the orange component of visible light. What is the colour of C?(1 mark)

Outcome(s): H13, H14

Sample answer: C is red, the complement of green, which is the colour absorbed most by C

Criteria	Mark(s)
correct colour	1

Beer's law works better if the source of radiation is monochromatic (consisting of only one or limited number of wavelengths). The light source can be made more monochromatic by the use of filters. In colorimery, filters may be coloured glasses which transmit the colour that it does not absorb. For example, a yellow tinted glass absorbs violet and transmits yellow.

Glass filter

I₀ → original intensity of light

solution

Iₜ → transmitted intensity

light source

(c)   What colour of filter should be used in the analysis of C to make the radiation *more monochromatic?*

 Answer: green

Criteria	Mark(s)
correct wavelength	1

Outcome(s):H13, H14

(d)   To analyse a substance colorimetrically, the following steps are followed:

   (1)   prepare a series of solutions with increasing concentrations of the substance

   (2)   measure the absorbance for each concentration

   (3)   construct an absorbance – concentration graph

   (4)   determine the concentration of the same substance of unknown concentration graphically.

Use the procedure given in (3) and (4) to solve the following problem: (6 marks)

Stainless Steel is an alloy of iron and a variety of other elements.

A 1.000 g sample of steel was dissolved, by reaction, in nitric acid and the manganese in the sample was oxidized to permanganate with potassium periodate. The solution was diluted to 500.0 mL and gave an absorbance reading of 2.3 at 520 nm. Standard permanganate solutions gave the following readings:

Concentration (mol L^{-1})	Absorbance
0.0010	1.0
0.0020	2.0
0.0030	3.0

(i)   Draw a labeled absorbance – concentration graph. (2 marks)

Sample Answer:

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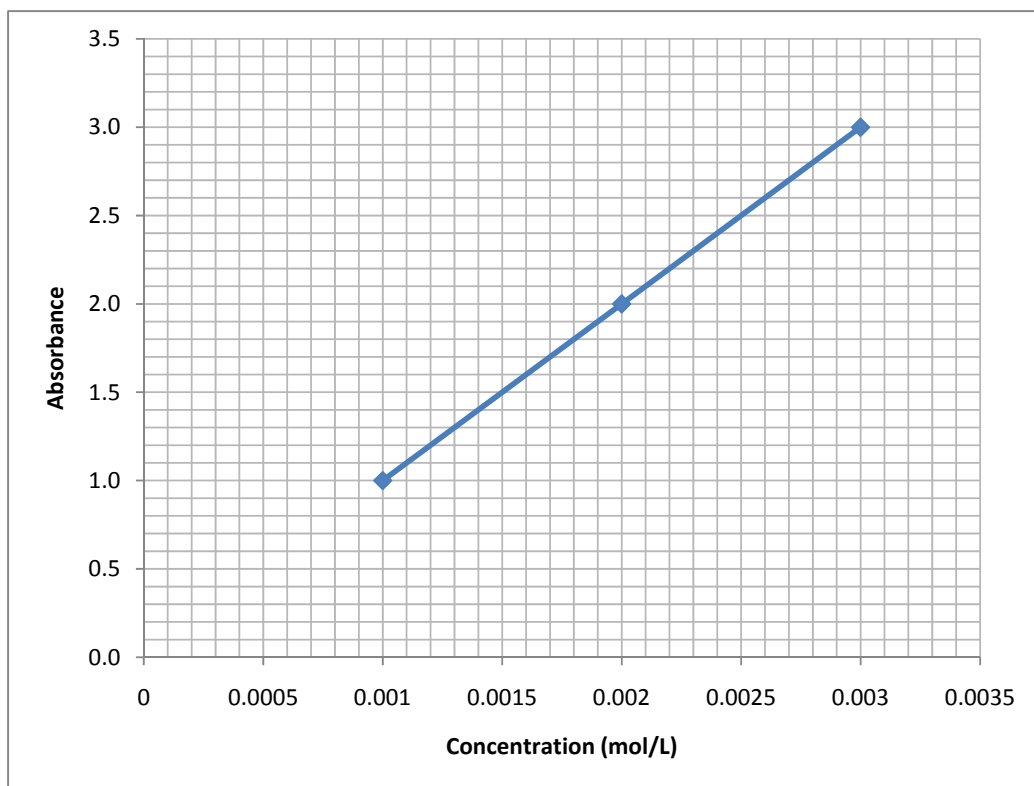
Criteria	Mark(s)
correct orientation of axes (dependent-independent variables) and axes labels	1
correct plotting of points	1

Outcome(s):H10, H13

(ii)   Graphically determine the concentration of the unknown permanganate solution. (1 mark)

From the graph , the concentration of the MnO_4^- solution is 0.0023 mol L^{-1} (1 mark)

Outcome(s):H10

(iii)   Calculate the percent manganese in the steel. (2 marks)

Sample Answer:

mol Mn = mol MnO_4^- = C x V = 0.0023 x 0.500 = 1.15 x 10^{-3} mol (1 mark)

mass Mn = mole Mn x molar mass of Mn = 1.15 x 10^{-3} mol x 54.94 g/mol = 0.0632 g

% Mn = $\dfrac{mass\ of\ Mn}{mass\ of\ sample}$ x 100% = $\dfrac{0.0632}{1.000}$ x 100% = 6.3% (1 mark)

Outcome(s):H10
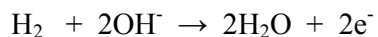
Question 2 (7 marks)

The Fuel cell

A fuel cell utilizes the reaction between oxygen and hydrogen to produce water. Unlike combustion, the energy is given out not as heat but as electricity. As reactants are used up more are added, so a fuel cell can give a continuous supply of electricity. The electrolyte is aqueous sodium hydroxide. It is contained within the cell using porous electrodes, which allow the passage of water, hydrogen and oxygen. Hydrogen is at the anode and oxygen is at the cathode.

The advantages of a fuel cell are that they do not need recharging nor do they pollute, as water is the only product. However they are very expensive to produce.
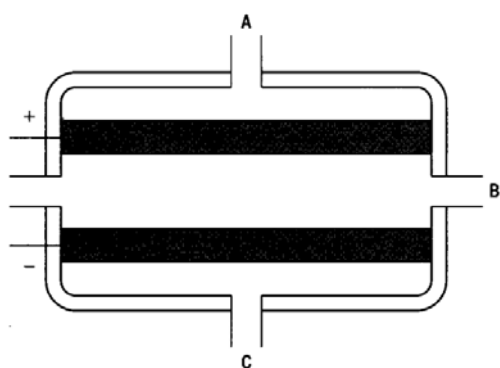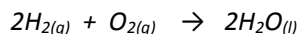

The diagram above shows some of the features of a hydrogen-oxygen fuel cell.

(a) Given the following half equations, determine the overall cell reaction.(1 mark)

$$H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$$

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

Sample Answers :

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$

Marking criteria	Marks
Correct reaction	1

a) At which point A, B, C is hydrogen passed into the cell ?
   Explain your answer. (2marks)

a) *Point C . H_2 is the reductant and is oxidized at the negative electrode(anode).*

Marking Criteria	Marks
Explanation and correct identification of Point C	2

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Identification of correct point C	1

b) Why do you think the fuel cell is considered as an alternative energy source to the combustion of fossil fuels ?(2marks)

b) *Fuel cells are more efficient as they convert chemical energy directly to electrical energy, and energy losses are minimized.*

Marking Criteria	Marks
Correct explanation of the use of the fuel – cell as an alternative fuel source.	1

c) *Any two of the following :*

- *Reaction rates at electrodes are slow.*
- *Fuel cells are expensive at present.*
- *The electrodes must be porous and act as catalysts, and so are expensive.*
- *Auxiliary systems are needed to pump the gases.*
- *Operating temperatures are high.*

Marking criteria	Mark
Two correct disadvantages of uses of the fuel cell	2
One correct disadvantage of the use of the fuel cell.	1

Outcome(s): H3, H4, H5, H7

Question 3 (6 marks) Refer to *Figure 1* in the Stimulus Booklet to answer Questions 3

(a) Calculate the total mass of fermentable sugars obtained from the processing of 200 wet tons of sugar cane ("field cane").(1 mark)

140/23.5 = 200/X X = 33.6 tons

(b) (i) What type of sugar constitutes the bulk of fermentable sugars? (1 mark)

Glucose

(ii) Calculate the % w/w of the sugar you gave in (b)(i) for the fermentable sugars. (1 mark)
57%

(c) Determine the % conversion from fermentation to carbon dioxide and ethanol.(1 mark)

70%

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Refer to *Figure 2* in the Stimulus Booklet to answer Question 4.

Question 4(4 marks)

(a)   Identify which alternative fuel has the most impact on greenhouse gas emissions. Explain how you derived your answer.(2 marks)

Coal-to-liquids without carbon capture and storage. This fuel will increase greenhouse gas emissions by 119%.

Marking criteria	Marks
Explanation includes numerical answer (119%)	2
Identification of coal-to-liquids without carbon capture…	1

(b)   Describe two other features the data reveals about the use of alternative fuels.(2 marks)

Cellulosic ethanol is the most beneficial alternative fuel since the use of this fuel will result in a decrease in greenhouse gas emissions of 91%.

Marking criteria	Marks
Description provided about a second feature	2
Description provided about one feature	1

Refer to *Figure 3* in the Stimulus Booklet to answer Questions 5.

Question 5 (3 marks)

(a)   Which plastics should aromatic hydrocarbon solvents not be used on?(1 mark)

PS, acrylic, PVC, PC

(b)   State the name of a polymer that would be the most suitable for containing vegetable oil.

PTFE or PFA (1 mark)

(c)   Identify a polymer that could tolerate all of the following conditions.

$120^{\circ}C$; can be sterilised using radiation or chemical means; clear; rigid; excellent resistance to mineral oils and dilute acids.
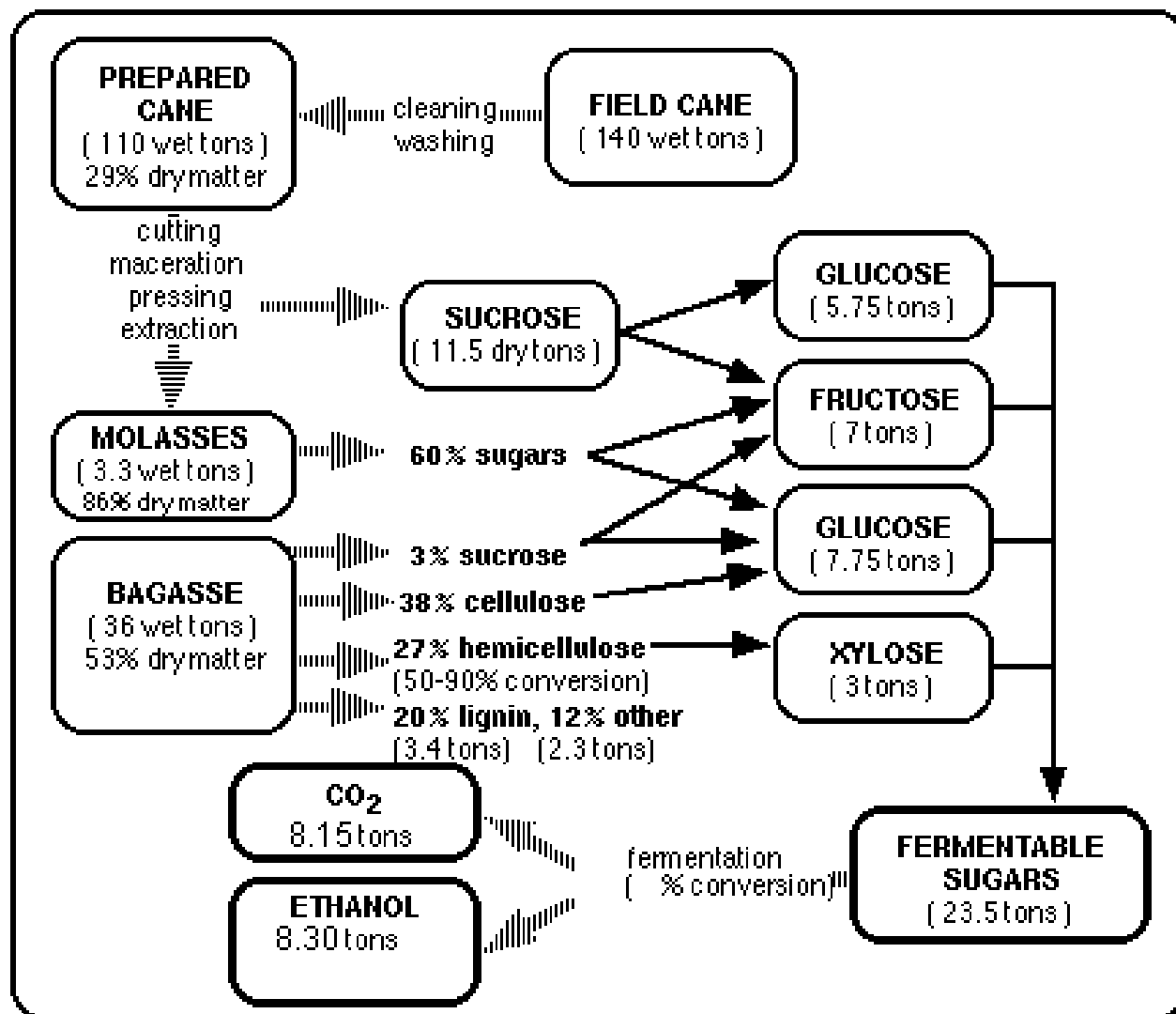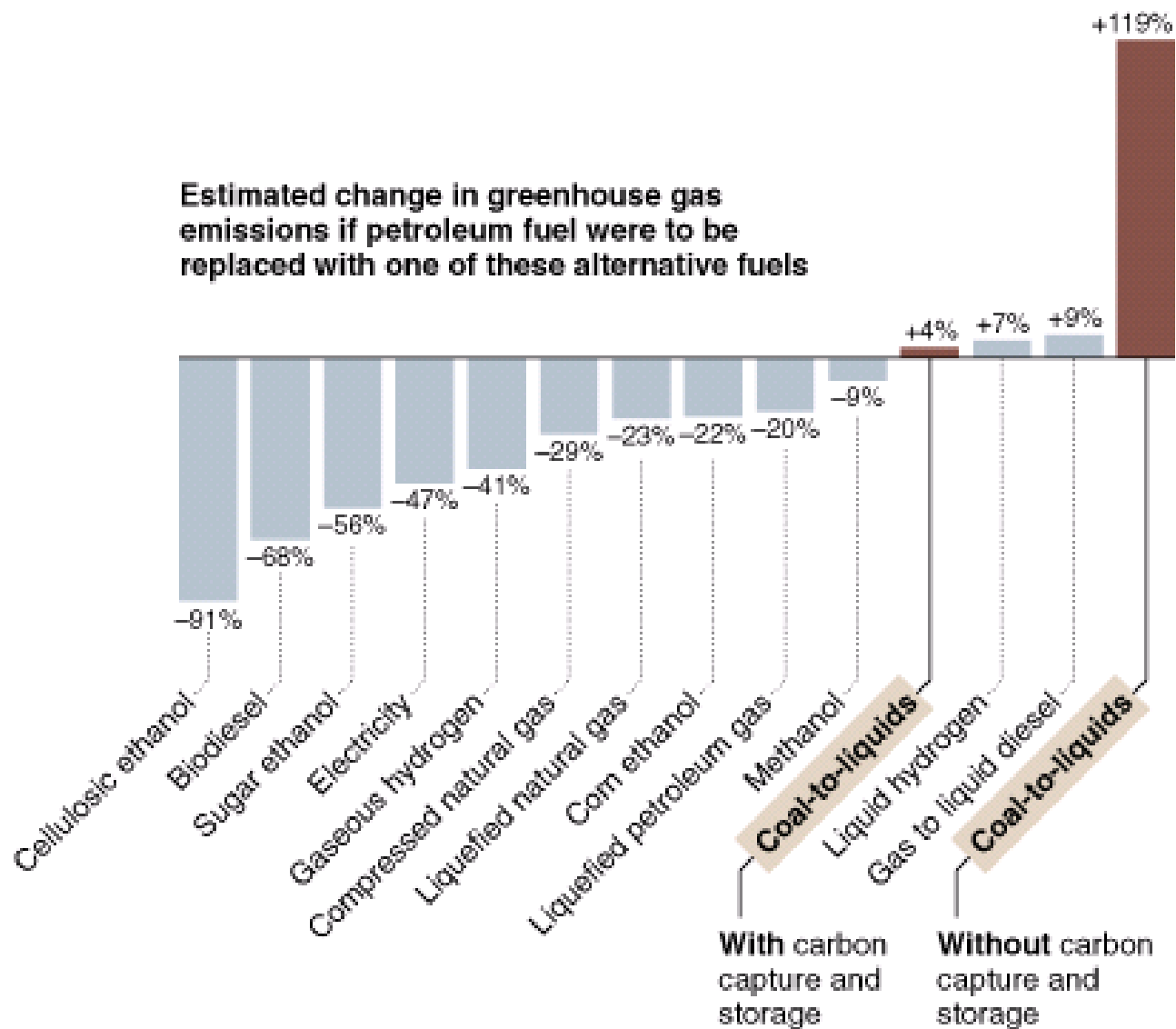
PC (1 mark)

Figure 1. Flow chart showing the sequence of steps involved for the processing of cane sugar for fermentation.

Estimated change in greenhouse gas emissions if petroleum fuel were to be replaced with one of these alternative fuels

+119%

+4% +7% +9%

−9%

−29% −23% −22% −20%

−47% −41%

−56%

−68%

−91%

Cellulosic ethanol
Biodiesel
Sugar ethanol
Electricity
Gaseous hydrogen
Compressed natural gas
Liquefied natural gas
Corn ethanol
Liquefied petroleum gas
Methanol
Coal-to-liquids
Liquid hydrogen
Gas to liquid diesel
Coal-to-liquids

With carbon capture and storage

Without carbon capture and storage

Note: The estimates include emissions from all parts of the process of making the fuels including fossil extraction, feedstock growth and distribution as well as averaging for the different methods of producing the fuels.

Source: Environmental Protection Agency   The New York Times

Figure 2. The change in greenhouse gas emissions if petroleum fuel were to be replaced with an alternative fuel.

Chemical Resistance and Physical Properties

Legend:
- ✓✓✓ (green) Excellent resistance, no attack.
- ✓✓ (blue) Good resistance, minor attack.
- ✓ (yellow) Limited resistance, moderate attack, suitable for short term use only.
- ✗ (red) Poor resistance, not recommended.
- — No information available.

Transparency: C Clear | TL Translucent | O Opaque
Flexibility: EX Excellent | R Rigid

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	LDPE	HDPE	PP	PPCO	PS	ACRYLIC	PTFE	PMP	PVC	PC	PFA
Acids - dilute	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Acids - concentrated	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✗	✓✓✓	✓✓✓	✓✓✓	✗	✓✓✓
Alcohols	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✗	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓
Aldehydes	✓✓	✓✓	✓✓	✓✓	✗	✓✓	✓✓✓	✓✓	✗	✓	✓✓✓
Bases	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✗	✓✓✓
Esters	✓✓✓	✓✓	✓✓	✓✓✓	✗	✗	✓✓✓	✓✓	✗	✗	✓✓✓
Hydrocarbons Aliphatic	✓	✓✓	✓✓	✓✓	✗	✓✓	✓✓✓	✓	✓✓✓	✗	✓✓✓
Hydrocarbons Aromatics	✓	✓✓	✓	✓	✗	✗	✓✓✓	✓	✗	✗	✓✓✓
Hydrocarbons Halogenated	✗	✓	✓	✓	✗	✗	✓✓✓	✗	✗	✗	✓✓✓
Ketones	✓✓	✓✓	✓✓	✓✓	✗	✗	✓✓✓	✓	✗	✗	✓✓✓
Oils, Minerals	✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Oil, Vegetable	✓✓	✓✓	✓✓	✓✓	✓✓	✗	✓✓✓	✓✓	✓✓	✓✓	✓✓✓
Oxidizing Agents	✓	✓	✓	✓	✗	✗	✓✓✓	✓	✓✓	✗	✓✓✓
Max Temp. °C	80	120	135	121	70	90	300	145	70	130	270
Min Temp. °C	-50	-100	0	-40	0	-60	-200	0	-25	-135	-260
Autoclavable	NO	NO	YES	YES	NO	NO	YES	YES	NO	YES	YES
Microwavability	YES	NO	YES	YES**	NO	NO	YES	YES	YES	YES**	YES
Gas Sterilization	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Dry Heat Sterilization	NO	NO	NO	NO	NO	NO	YES	YES	NO	NO	YES
Gamma Irradiation Sterilization	YES	YES	NO	NO	YES	YES	NO	YES	NO	YES	YES
Chemical Disinfectant Sterilization	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	YES
Transparency	TL	TL	TL	TL	C	C	O	C	C	C	TL
Flexibility	EX	R	R	R	R	R	R	R	R	R	R
Gas Permeability N$_2$	20	3	4.4	4.2	3	-	-	65	0.4	3	-
Gas Permeability CO$_2$	280	45	92	65	75	-	-	-	10.2	85	-
Gas Permeability O$_2$	60	10	28	24	15	-	-	270	1.2	20	-
Water Absorption %	<0.01	<0.01	<0.02	<0.02	0.05	0.3	0.3	<0.01	0.06	0.35	<0.03
Resistivity Ohm CM^2	>10^{15}	>10^{15}	>10^{16}	>10^{16}	>10^{16}	>10^{14}	>10^{18}	>10^{16}	<10^{16}	2×10^{16}	10^{18}
Non-Cytotoxicity*	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Specific Gravity	0.92	0.95	0.90	0.90	1.05	1.18	2.2	0.83	1.34	1.20	2.16

* "YES" is based on the material being determined to be non-cytotoxic based on USP and ASTM biocompatibility testing standards using an MEM elution technique on a W138 human diploid lung cell line.

** Material will absorb heat.

Figure 3. Chemical and physical properties of select polymers (LDPE, HDPE, PP, PPCO, PS, Acrylic, PTFE, PMP, PVC, PC, PFA).

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