Family Name (please print carefully!)____________________________________________

Given Name (please print carefully!)_____________________________________________

Student Number __________________________ Signature ________________________

Please indicate your section with an “X” in the list column:

| Section 01 | MWF 8:30 am       | Dr. K. Brown |
| Section 03 | MWF 9:30 am       | Dr. A. Grosvenor |
| Section 05 | TTh 10:00 am      | Dr. A. Baranski |
| Section 91 | TTh 8:30 am       | Dr. L. Wilson |
| Section 97 | Muenster          | Dr. A. Szmigielski |
| Section C11| Melfort           | Dr. A. Szmigielski |
| Section C15| Prince Albert     | Dr. P. Ahiahonu |
| Section C51| North Battleford  | Dr. K. Pasha |

INSTRUCTIONS - PLEASE READ THIS FIRST!

a. This is a closed-book examination. A data-sheet with a Periodic Table accompanies this examination paper; no other paper (or device) containing information relevant to this exam is permitted.

b. Simple scientific calculators (maximum two-line display) are permitted; graphing calculators, PDA's, electronic dictionaries, etc., are not.

c. This examination paper has 13 pages; ensure that your copy is complete.

d. Answer multiple choice questions in Section A by circling a response on this paper AND by filling in the corresponding response on the blue opscan sheet USING ONLY A SOFT-LEAD PENCIL. No deductions will be made for incorrect answer. Multiple answers will be treated as NO answer; if you change your mind, erase carefully. In the event of a discrepancy between an answer on the examination paper and on the computer sheet, the response on the opscan sheet will count.

e. Answer the questions in Section B on this examination paper. Show all work; this will be graded.

f. If you have not already done so, please fill out the top of this paper now, and write your name (legibly!) and code your student number on the computer blue sheet in soft pencil.

g. You can use the backsides of the 13 pages as scratch paper (more paper will be available on request).

<table>
<thead>
<tr>
<th>Questions</th>
<th>Maximum Marks</th>
<th>Marks Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section A (Q1 – Q40)</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Section B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QB1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>QB2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>QB3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>QB4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
PART A

1. What is the formula for the simple oxide of strontium?

A. SrO  
B. Sr₂O  
C. SrO₂  
D. Sr₂O₂  
E. None of the above

2. If 0.351 mols of a substance weighs 65.3 g, what is the molar mass of the substance?

A. 5.38×10⁻³ g/mol  
B. 2.29×10⁻¹ g/mol  
C. 1.86×10² g/mol  
D. 3.54×10⁻³ g/mol  
E. None of the above

3. When the structure of a molecule is represented using a space-filling model, what part of the atoms do the interconnected spheres represent?

A. Nuclei of atoms  
B. Individual electrons  
C. Electron clouds  
D. Electromagnetic shield  
E. None of the above

4. Based on what we learned in class, what is the name of the following ionic compound, FePO₄?

A. Iron (III) phosphate  
B. Iron (II) phosphate  
C. Iron (III) phosphite  
D. Ferrous phosphate  
E. None of the above

5. In the following reaction, how many grams of O₂(g) are formed if the initial mass of CO₂(g) is 40.00 g and H₂O is available as an excess reagent?

\[6 \text{CO}_2(g) + 6 \text{H}_2\text{O}(l) \xrightarrow{\Delta} 6 \text{O}_2(g) + 6 \text{C}_6\text{H}_{12}\text{O}_6(aq)\]

A. 192.4g  
B. 87.25g  
C. 29.08g  
D. 174.5g  
E. 96.23g

6. To what volume should you dilute 0.600 L of 10.5 M NaOH to make 5.00 M NaOH?

A. 0.600 L  
B. 1.40 L  
C. 1.26 L  
D. 0.900 L  
E. 1.80 L
7. For the following reaction, what is the limiting reagent if you have 30.00 g of Fe and 2.00 mols of HBr?

\[ \text{Fe(s)} + 2\text{HBr(aq)} \rightarrow \text{FeBr}_2(\text{aq}) + \text{H}_2(\text{g}) \]

A. Fe  
B. HBr  
C. FeBr\(_2\)  
D. H\(_2\)  
E. The reagents are given in the correct proportion

8. Complete and balance the following reaction: \(\text{H}_3\text{PO}_4(\text{aq}) + \text{NaOH(}a\text{q)} \rightarrow \cdot \)

A. \(\text{H}_3\text{PO}_4(\text{aq}) + \text{NaOH(}a\text{q)} \rightarrow \text{H}_2\text{O(}l\text{)} + \text{Na}_3\text{PO}_4(\text{aq})\)  
B. \(\text{H}_3\text{PO}_4(\text{aq}) + \text{NaOH(}a\text{q)} \rightarrow 2\text{H}_2\text{O(}l\text{)} + \text{NaPO}_4(\text{aq})\)  
C. \(\text{H}_3\text{PO}_4(\text{aq}) + 3\text{NaOH(}a\text{q)} \rightarrow 3\text{H}^+(\text{aq}) + 3\text{OH}^-(\text{aq}) + 3\text{Na}^+(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq})\)  
D. \(\text{H}_3\text{PO}_4(\text{aq}) + 3\text{NaOH(}a\text{q)} \rightarrow 3\text{H}_2\text{O(}l\text{)} + \text{Na}_3\text{PO}_4(\text{aq})\)  
E. \(2\text{H}_3\text{PO}_4(\text{aq}) + 6\text{NaOH(}a\text{q)} \rightarrow 5\text{H}_2\text{O(}l\text{)} + 2\text{Na}_3\text{PO}_4(\text{aq})\)

9. Balance the following REDOX reaction occurring in acidic solution.

\[ \text{NO}_3^-(\text{aq}) + \text{Sn}^{2+}(\text{aq}) \rightarrow \text{Sn}^{4+}(\text{aq}) + \text{NO}(\text{g}) \]

A. \(\text{NO}_3^-\text{(aq)} + \text{Sn}^{2+}\text{(aq)} + 8\text{H}^+(\text{aq}) \rightarrow \text{Sn}^{4+}\text{(aq)} + \text{NO}(\text{g}) + \text{H}_2\text{O(}l\text{)}\)  
B. \(2\text{NO}_3^-\text{(aq)} + 3\text{Sn}^{2+}\text{(aq)} \rightarrow 3\text{Sn}^{4+}\text{(aq)} + 2\text{NO}(\text{g})\)  
C. \(4\text{NO}_3^-\text{(aq)} + 6\text{Sn}^{2+}\text{(aq)} + 8\text{H}^+(\text{aq}) \rightarrow 6\text{Sn}^{4+}\text{(aq)} + 4\text{NO}(\text{g}) + 8\text{H}_2\text{O(}l\text{)}\)  
D. \(\text{NO}_3^-\text{(aq)} + 2\text{Sn}^{2+}\text{(aq)} + 4\text{H}^+(\text{aq}) \rightarrow 2\text{Sn}^{4+}\text{(aq)} + \text{NO}(\text{g}) + 2\text{H}_2\text{O(}l\text{)}\)  
E. \(2\text{NO}_3^-\text{(aq)} + 3\text{Sn}^{2+}\text{(aq)} + 8\text{H}^+(\text{aq}) \rightarrow 3\text{Sn}^{4+}\text{(aq)} + 2\text{NO}(\text{g}) + 4\text{H}_2\text{O(}l\text{)}\)

10. A sample of \(\text{CO}_2(\text{g})\) has a pressure of 0.75 atm and temperature of 30 °C, calculate the density of this gas.

A. 1.0 g/L  
B. 1.3 g/L  
C. 0.65 g/L  
D. 0.85 g/L  
E. 13 g/L

11. At high pressure (>400 atm), gases like Ar, Ne, and Xe are found to have molar volumes that are larger than those predicted by the ideal gas law. Which statement below best explains why this is the case.

A. The molar volume is larger than predicted because of interatomic attraction.  
B. The molar volume is larger than predicted because of changes in kinetic energy.  
C. The molar volume is larger than predicted because real gas atoms take up space.  
D. The molar volume is larger than predicted because of atomic collisions.  
E. The statement is incorrect; the ideal gas law predicts the molar volume perfectly.
12. What volume of Cl\(_2\) (g) is required to completely react with 5.50 g of Na\(_{(s)}\) at 400.0 K and 0.500 atm to form NaCl\(_{(s)}\)?

\[ 2\text{Na}_{}(s) + \text{Cl}_2(g) \rightarrow 2\text{NaCl}_{}(s) \]

A. 3.65 L  
B. 15.7 L  
C. 6.50 L  
D. 7.85 L  
E. 9.26 L

13. Which of the following orbitals cannot exist?

A. 6s  
B. 3d  
C. 3f  
D. 4p  
E. All can exist

14. The lowest frequency of radiation that can dissociate one \( \text{O}_2\) (g) molecule in the upper atmosphere into two oxygen atoms is \( 1.237 \times 10^{15} \) Hz. For 1 mole of photons of this frequency, what is the energy in joules per mol of these photons?

A. \( 1.237 \times 10^{15} \) J/mol  
B. \( 8.196 \times 10^{-19} \) J/mol  
C. \( 2.424 \times 10^{-19} \) J/mol  
D. \( 4.936 \times 10^{5} \) J/mol  
E. None of the above

15. How many electrons can be accommodated in the \( n=3 \) principal shell?

A. 2  
B. 8  
C. 10  
D. 12  
E. 18

16. Which of the following electron configurations is a correct electron configuration for the ground state of an atom:

A. \([\text{Ne}]3s^13p^6\)  
B. \([\text{Ne}]3s^23p^6\)  
C. \([\text{Ne}]3s^23p^54s^23d^2\)  
D. \([\text{Ne}]3s^23p^64s^23d^{11}\)  
E. None of the above

17. Which of the following elements is the strongest oxidizing agent?

A. Cs  
B. He  
C. \( \text{O}_2 \)  
D. \( \text{F}_2 \)  
E. C
18. Which of the following species are diamagnetic: Be, Na, Ne, S\(^2^\), B, Fe\(^{3+}\)

A. Be, S\(^2^\), Ne
B. Na, S\(^2^\), Fe\(^{3+}\)
C. B, Fe\(^{3+}\), S\(^2^\)
D. Na, B, Fe\(^{3+}\)
E. Ne, S\(^2^\), B

19. According to Hund's rule, which atom is expected to contain unpaired electrons?
A. Sr
B. Cd
C. Ge
D. Kr
E. None of the above

20. The first four ionization energies of an element are (in kJ/mol) 899, 1757, 14850 and 21005. To which group (column in the Periodic Table) does this element belong?
A. 1A
B. 2A
C. 3A
D. 4A
E. 5A

21. The atomic species Kr, Br\(^-\), Se\(^2^-\) and Rb\(^+\) are isoelectronic. What is the correct order of decreasing radius of these species? (The symbol "\(>\)" means "greater than").
A. Br\(^-\) > Rb\(^+\) > Kr > Se\(^2^-\)
B. Rb\(^+\) > Kr > Br\(^-\) > Se\(^2^-\)
C. Se\(^2^-\) > Br\(^-\) > Kr > Rb\(^+\)
D. Kr > Rb\(^+\) > Se\(^2^-\) > Br\(^-\)
E. None of the above.

22. Which term best describes the bonding between hydrogen and bromine atoms in HBr? The electronegativity values for these elements are Br (2.8) and H (2.1).
A. Ionic bonding
B. Hydrogen bonding
C. Polar covalent bonding
D. Covalent bonding
E. Pure covalent bonding

23. Order the following diatomic compounds from most polar to least polar covalent bonds: i) Br–Br, ii) Cl–F, iii) Br–Cl, and iv) Cl–I. The electronegativity values for each element are as follows: F (4.0), Cl (3.0), Br (2.8) and I (2.5).
A. Cl–F > Br–Cl > Br–Br > Cl–I
B. Br–Cl > Cl–F > Br–Br > Cl–I
C. Br–Cl > Cl–I > Br–Br > Cl–F
D. Cl–F > Cl–I > Br–Cl > Br–Br
E. None of the above.
A droplet of water (H$_2$O) is attracted to a statically (i.e. electrically) charged glass rod while a droplet of cyclohexane (C$_6$H$_{12}$) is unaffected. Choose the statement that best describes the reason for this observation.

A. the molecular mass of cyclohexane is greater than water
B. the intermolecular interactions for cyclohexane are greater than those in water
C. water has a lower boiling point than cyclohexane
D. water is a more polar molecule than cyclohexane
E. the density of water is greater than cyclohexane

Which of the following molecules has a dipole moment?

A. CF$_4$
B. F$_2$
C. BF$_3$
D. XeF$_2$
E. SF$_4$

The molecular geometry of the BrF$_3$ molecule is

A. Tetrahedral
B. Trigonal pyramidal
C. Trigonal planar
D. T-shaped
E. Seesaw

In accordance with the octet rule for Lewis structures, the bond between carbon and nitrogen atoms in the cyanide ion (CN$^-$) consists of

A. One sigma bond only
B. Three pi bonds
C. Two sigma bonds and one pi bond
D. One sigma bond and two pi bonds
E. One sigma bond and one pi bond

The formal charges of carbon and oxygen respectively in the carbon monoxide molecule are:

A. 0, 0
B. +1, −1
C. −1, +1
D. −2, +2
E. −1, 0

The O–N–O bond angle in NO$_2^-$ is:

A. 180°
B. 109.5°
C. 120°
D. slightly less than 120°
E. 90°
30. The hybridization of orbitals on the central iodine atom in the triiodide anion (I$_3^-$) is:

A. sp
B. sp$^2$
C. sp$^3$
D. sp$^3$d
E. sp$^3$d$^2$

31. At room temperature CBr$_4$ is less volatile (lower vapour pressure) than CF$_4$. This is because

A. CBr$_4$ has stronger dipole-dipole intermolecular forces than CF$_4$.
B. CBr$_4$ has lower ionization energy than CF$_4$.
C. CBr$_4$ has stronger London (dispersion) forces than CF$_4$.
D. Br is more electronegative than F.
E. None of the above.

32. Choose the compound that exhibits hydrogen bonding as its strongest intermolecular force.

A. SCl$_2$
B. CH$_3$OH
C. C$_2$H$_6$
D. CH$_2$F$_2$
E. None of the above compounds exhibit hydrogen bonding.

33. Choose the substance with the highest surface tension.

A. CH$_3$CH$_2$CH$_3$
B. CH$_2$F$_2$
C. CH$_3$CH$_2$F
D. HOCH$_2$CH$_2$OH
E. CH$_3$COCH$_3$

34. Which of the following is considered a molecular solid?

A. NH$_4$NO$_3$
B. Xe
C. Cu
D. I$_2$
E. None of these is a molecular solid.

35. Which of the following is considered an ionic solid?

A. XeF$_4$
B. (NH$_4$)$_2$CO$_3$
C. CCl$_4$
D. SeBr$_2$
E. None of these is an ionic solid.

36. Choose the substance with the highest viscosity.

A. CF$_4$
B. (CH$_3$CH$_2$)$_2$CO
C. HOCH$_2$CH$_2$CH$_2$CH$_2$OH
D. C$_2$H$_4$Cl$_2$
E. C$_6$H$_{14}$
37. Consider the phase diagram below. If the dashed line at 1 atm of pressure is followed from 100 to 500 °C, what phase changes will occur (in order of increasing temperature)?

![Phase Diagram](image)

A. sublimation, followed by deposition  
B. vaporization, followed by deposition  
C. fusion, followed by vaporization  
D. condensation, followed by vaporization  
E. No phase change will occur under the conditions specified.

38. Which of the following substances should have the highest melting point?

A. Ar  
B. N₂  
C. CO  
D. Ne  
E. Fe

39. Which is the correct definition of the critical point of a substance?

A. The temperature where 50% of the solid substance has melted.  
B. The unique temperature and pressure where the liquid and vapour phases of the substance become indistinguishable.  
C. The unique temperature and pressure where all states of matter exist in equilibrium.  
D. The point on the phase diagram where the fusion curve, the sublimation curve and the vapour pressure curve intersect.  
E. The boiling point of the liquid phase when the barometric pressure is 1 atm.

40. Which of the following would be expected to have the lowest vapor pressure at room temperature?

A. Ethanol, bp = 78°C  
B. Methanol, bp = 65°C  
C. Water, bp = 100°C  
D. Acetone, bp = 56°C  
E. Boiling point of a liquid is not related to its vapor pressure
PART B

Use the available space to answer the following questions.

B1. (10 marks)
During the reaction of Al metal and sulphuric acid (H₂SO₄(aq)), Al₂(SO₄)₃(aq) and hydrogen gas (H₂(g)) are formed. Answer the following questions regarding this reaction.

(Answers provided without supporting work will receive only partial marks. All numerical answers should be written using 3 significant figures)

i) What is the name of Al₂(SO₄)₃? (1 mark)
Aluminum sulfate

ii) Write the balanced equation for this chemical reaction. (2 marks)
2Al(s) + 3H₂SO₄(aq) → Al₂(SO₄)₃(aq) + 3H₂(g)
Or 2Al(s) + 6H⁺(aq) → 2Al³⁺(aq) + 3H₂(g)

iii) How would you classify this reaction (circle the correct term)? (1 mark)
Precipitation                     Acid-base
Reduction-oxidation

iv) If 5.00 g of Al is reacted with 100.0 mL of 6.00 M H₂SO₄(aq), what is the limiting reagent? (2.5 marks)

\[ n_{Al} = \frac{5.00 \text{ g}}{26.98 \text{ g/mol}} = 0.185 \text{ mol}, \quad n_{H_2SO_4} = 0.1000 \text{ L} \times 6.00 \text{ mol/L} = 0.600 \text{ mol} \]

Al is the limiting reagent because \( \frac{n_{Al}}{2} = 0.0925 \text{ mol} < \frac{n_{H_2SO_4}}{3} = 0.200 \text{ mol} \)

v) Using the information provided in (iv), calculate the mass of Al₂(SO₄)₃(aq) formed. (1 mark)

\[ \frac{n_{Al_2(SO_4)_3}}{n_{Al}} = \frac{1}{2} \Rightarrow n_{Al_2(SO_4)_3} = \frac{1}{2} n_{Al} = 0.0925 \text{ mol} \]

\[ m_{Al_2(SO_4)_3} = M_{Al_2(SO_4)_3} \times n_{Al_2(SO_4)_3} = 342.15 \frac{g}{\text{mol}} \times 0.0925 \text{ mol} = 31.6 \text{ g} \]

vi) Using the ideal gas law, calculate the volume of H₂(g) formed if the reaction is performed under STP (standard temperature and pressure) conditions. (2.5 marks)

\[ \frac{n_{H_2}}{n_{Al}} = \frac{3}{2} \Rightarrow n_{H_2} = \frac{3}{2} n_{Al} = 0.2775 \text{ mol} \]

\[ V_{H_2}^{(STP)} = n_{H_2} \cdot V_m = 0.2775 \text{ mol} \times 22.414 \frac{L}{\text{mol}} = 6.22 \text{ L} \]
B2. (9 marks)
a. Light having a wavelength of \(2.50 \times 10^{-7} \text{ m}\) falls upon the surface of a piece of chromium in an evacuated glass tube causing an emission of electrons from the metal due to **photoelectric effect**. 

i) If the binding energy of electrons in chromium is \(7.21 \times 10^{-19} \text{ J}\), determine the kinetic energy of the emitted electrons. (3 marks) 

\[
KE = h \nu - \phi = \frac{h \cdot c}{\lambda} - \phi = \frac{6.6261 \times 10^{-34} \text{ Js} \cdot 2.9979 \frac{m}{s}}{2.50 \times 10^{-7} \text{ m}} - 7.21 \times 10^{-19} \text{ J} = 7.95 \times 10^{-19} \text{ J} - 7.21 \times 10^{-19} \text{ J} \\
= 7.4 \times 10^{-20} \text{ J}
\]

ii) What is the maximum wavelength of light for which electrons can be emitted from chromium? (3 marks)

Since the minimum value of KE is 0:

\[
\frac{h \cdot c}{\lambda_{\text{max}}} = \phi
\]

And

\[
\lambda_{\text{max}} = \frac{h \cdot c}{\phi} = \frac{6.6261 \times 10^{-34} \text{ Js} \cdot 2.9979 \frac{m}{s}}{7.21 \times 10^{-19} \text{ J}} = 2.76 \times 10^{-7} \text{ m}
\]

b. Boron has only two naturally occurring isotopes. The mass of boron-10 is 10.01294 amu and the mass of boron-11 is 11.00931 amu. Using the atomic mass of boron from the Periodic Table of elements, calculate the relative abundance of the two isotopes. (3 marks)

\[
\bar{M} = f_1 \cdot M_1 + f_2 \cdot M_2 \quad \text{and} \quad f_1 + f_2 = 1
\]

Therefore:

\[
\bar{M} = f_1 \cdot M_1 + M_2 - f_1 \cdot M_2
\]

And

\[
f_1 = \frac{\bar{M} - M_2}{M_1 - M_2} = \frac{10.811 \text{ amu} - 11.00931 \text{ amu}}{10.01294 \text{ amu} - 11.00931 \text{ amu}} = -0.1983 \text{ amu} = 0.199
\]

The abundance of \(^{10}\text{B}\) is 19.9% and \(^{11}\text{B}\) 80.1%.
**B3 (11 marks)**

i) Fill in the blanks in the table. A sample row has been filled in for you. The central atom in each case is underlined. *(9 marks)*

<table>
<thead>
<tr>
<th>Molecule or ion</th>
<th>Lewis Dot Structure</th>
<th>Electron Group Geometry*</th>
<th>Molecular Geometry**</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_2$O</td>
<td><img src="image" alt="Lewis Dot Structure" /></td>
<td>tetrahedral</td>
<td>bent</td>
</tr>
<tr>
<td>Ozone O$_3$</td>
<td><img src="image" alt="Lewis Dot Structure" /></td>
<td>trigonal planar</td>
<td>bent or angular</td>
</tr>
<tr>
<td>H$_2$SO$_4$</td>
<td><img src="image" alt="Lewis Dot Structure" /> (#)</td>
<td>tetrahedral</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>N$_2$H$_4$</td>
<td><img src="image" alt="Lewis Dot Structure" /></td>
<td>tetrahedral</td>
<td>trigonal pyramidal</td>
</tr>
</tbody>
</table>

*You may give a verbal description OR a drawing. In the case of a drawing, it must be unambiguous, with important bond angles indicated.*

**Describe the arrangement of ATOMS around the central (underlined) atom.**

(For H$_2$SO$_4$, I suggest accepting also the Lewis Structure with two double bonds between S and two terminal Os (as written in the textbook).)

ii) Describe polarity of ozone molecule by circling the correct answers below. *(2 marks)*

Bonds in ozone are: *pure covalent*  

Ozone molecule: *doesn’t have permanent dipole moment*  

*has permanent dipole moment*
B4 (10 marks)

a. The following graph plots the normal boiling points for CO$_2$, CH$_2$Cl$_2$, SO$_2$ and Cl$_2$.

Use your knowledge of intermolecular forces to fill in the boxes below (i.e. identify species compounds A, B, C and D). *Hint*: drawing the Lewis structures may be helpful. (4 marks)

Species “A” is CH$_2$Cl$_2$

Species “B” is SO$_2$

Species “C” is Cl$_2$

Species “D” is CO$_2$

b. Metallic iron crystallizes in a cubic lattice with the unit cell edge length equal to 287 pm. The density of iron is 7.87 g/cm$^3$.

i) Calculate mass of the unit cell of iron. (2 marks)

\[
m_{cell} = V_{cell} \cdot d_{Fe} = (l_{cell})^3 \cdot d_{Fe} = (287 \times 10^{-12} \text{ m})^3 \cdot 10^6 \text{ cm}^3 \cdot 7.87 \frac{\text{g}}{\text{cm}^3} = 1.86 \times 10^{-22} \text{ g}
\]

ii) How many iron atoms are in the unit cell? (2 marks)

\[
N_{Fe} = n_{Fe} \cdot N_A = \frac{m_{cell}}{M_{Fe}} \cdot N_A = \frac{1.86 \times 10^{-22} \text{ g}}{55.847 \frac{\text{g}}{\text{mol}}} \cdot 6.0221 \times 10^{23} \text{ mol}^{-1} = 2.01
\]

There are two Fe atoms per unit cell.

iii) The unit cell of iron is (circle the correct name): (2 mark)

- **Simple Cubic**
- **Body-centered Cubic**
- **Face-centered Cubic**

THE END
### Periodic Table of the Elements

<table>
<thead>
<tr>
<th>1A</th>
<th>2A</th>
<th>3A</th>
<th>4A</th>
<th>5A</th>
<th>6A</th>
<th>7A</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>1</td>
<td>He</td>
<td>2</td>
<td>Ne</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Li</td>
<td>Na</td>
<td>K</td>
<td>3</td>
<td>Rb</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Be</td>
<td>Mg</td>
<td>Ca</td>
<td>4</td>
<td>Sr</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Ne</td>
<td>13</td>
<td>Ar</td>
<td>5</td>
<td>Cs</td>
<td>35</td>
<td>18</td>
</tr>
<tr>
<td>2A</td>
<td>3A</td>
<td>4A</td>
<td>5A</td>
<td>6A</td>
<td>7A</td>
<td>8A</td>
</tr>
<tr>
<td>Li</td>
<td>Na</td>
<td>K</td>
<td>3</td>
<td>Rb</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Be</td>
<td>Mg</td>
<td>Ca</td>
<td>4</td>
<td>Sr</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Ne</td>
<td>13</td>
<td>Ar</td>
<td>5</td>
<td>Cs</td>
<td>35</td>
<td>18</td>
</tr>
</tbody>
</table>

### Physical Constants

<table>
<thead>
<tr>
<th>Constant</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atomic mass unit</td>
<td>$u$</td>
<td>$1.6605 \times 10^{-27}$ kg</td>
</tr>
<tr>
<td>Avogadro number</td>
<td>$N_A$</td>
<td>$6.0221 \times 10^{23}$ mol$^{-1}$</td>
</tr>
<tr>
<td>Gas Constant</td>
<td>$R$</td>
<td>$0.082058 \text{ L atm mol}^{-1} \text{K}^{-1}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$8.3145 \text{ J K}^{-1} \text{mol}^{-1}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$62.364 \text{ L mmHg mol}^{-1} \text{K}^{-1}$</td>
</tr>
<tr>
<td>Molar volume of an ideal gas at STP</td>
<td>$V_m$</td>
<td>$22.414 \text{ L mol}^{-1}$</td>
</tr>
<tr>
<td>Planck constant</td>
<td>$h$</td>
<td>$6.626 \times 10^{-27}$ J s</td>
</tr>
<tr>
<td>Speed of light in a vacuum</td>
<td>$c$</td>
<td>$2.997 \times 10^{8}$ m s$^{-1}$</td>
</tr>
<tr>
<td>Rydberg Constant</td>
<td>$R_H$</td>
<td>$2.179 \times 10^{-15}$ J</td>
</tr>
<tr>
<td>Electron mass</td>
<td>$m_e$</td>
<td>$9.109 \times 10^{-31}$ kg</td>
</tr>
</tbody>
</table>

### Some SI Derived Units

<table>
<thead>
<tr>
<th>Physical Quantity</th>
<th>Unit</th>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td>Newton</td>
<td>N</td>
<td>kg m s$^{-2}$</td>
</tr>
<tr>
<td>Energy</td>
<td>Joule</td>
<td>J</td>
<td>kg m$^2$ s$^{-2}$</td>
</tr>
<tr>
<td>Pressure</td>
<td>Pascal</td>
<td>Pa</td>
<td>N m$^{-2}$ = kg m$^{-1}$ s$^{-2}$</td>
</tr>
</tbody>
</table>

### STP Conditions

$P = 1$ atm = 760 torr = 760 mmHg = 101.325 kPa, Temperature = 0 °C = 273.2 K

### Heisenberg Uncertainty Principle

$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$, de Broglie's wavelength of particles: $\lambda = \frac{h}{m \cdot u}$

### Photoelectric effect relationship

$KE = h \nu - \phi$