PISA BASED SCIENCE PRACTICE QUESTIONS TO DEVELOP CREATIVE AND CRITICAL THINKING SKILL

GENERAL INSTRUCTIONS

1. There are overall 10 questions

2. Five questions from Matter in Our Surroundings and five questions are from Periodic Classification of Elements.

3. Each question is of 10 marks.

4. Internal split up of marks is provided before each sub question.

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MATTER IN OUR SURROUNDINGS

1. MATTER

Matter is defined as that which has mass and occupies space. This definition seems simple enough, yet there are profound issues which surround it. For example, there is currently no generally accepted scientific theory for why mass exists. It can be defined: mass characterizes an object's resistance to a change in its motion. But why it exists cannot yet be demonstrated. Mass just is, it just exists. As we look into it more, definitions start to become circular, as in the definition of space: space is that which is occupied by matter. So, any definition of space exists only if there is matter. Take the matter away and space ceases to exist.

All matter is particulate in nature. This basically means that between separate bits of matter there are spaces which contain no matter. In science it is called the "atomic nature of matter." It is generally agreed that the Greek philosopher Leucippus and his student Democritus were the first to propose this idea, about 440 B.C. This "atomic theory" was opposed by Aristotle 100 years later, who taught that all space is filled with matter, that there are no empty spaces. Aristotle's ideas were accepted as correct by almost all educated people, until the early 1800's, when atomic ideas began to be more generally accepted as correct. Today, we know that there are many different particles which make up matter. Some are long-lasting, such as the proton, while others are very, very short-lived, such as the top quark. The primary "particle" in chemistry is the atom. However, you probably know that there is a substructure to an atom; that it is made of protons, neutrons and electrons. You may also know that protons and neutrons are each made of three quarks. There are many other particles beyond the proton and neutron, some containing two quarks and some containing three.

There are two other categories of particles which appear to NOT be made of quarks: electrons and neutrinos. As far as science is currently able to tell, there are three types of particles with no substructure that we can detect: quarks, electrons and neutrinos. It may be that someday we will learn the electron, for example, is made of still smaller pieces like an atom is made of protons, neutrons and electrons. That would be pretty cool!

Q1. How is space related to matter? (1)

Ans1. Space is that which is occupied by matter.

Q2. How Aristotle theory opposed modern theory of atoms? (2)

A2. According to Aristotle all space is filled with matter whereas according to modern theory atoms have space between them where nothing exists.

Q3. What is primary particle of matter? (1)

A3. Atom

Q4. What are substructures of atoms? (2)

A4. Electron proton and neutron.

Q5, Name the particles used for making proton and neutron? (2)

A5. Quarks

Q6. Give any two particles which have no substructure. (2)

A6. Quarks, electrons and neutrinos(any two).

2. Characteristics of Particles of Matter

Every substance is made up of particles. These particles exhibit some characteristics. They can influence the state and properties of a substance. The three characteristics shown by particles of matter are as follows.

Particles Have Space Between Them

There are small voids between every particle in a matter. This characteristic is the concept behind the solubility of a substance in other substances. Take a glass of water. Put a teaspoon of salt/sugar and mix them properly. You will observe that the volume of water has not changed. This is because the particles of salt/sugar get into the inter-particle spaces between the water particles. This proves that there are voids between particles of a substance. If you add more salt/sugar, it will dissolve until all the space between water particles get filled. When all the voids are filled solution is said to be saturated and now further dissolving is not possible.

Particles Are Constantly in Motion

Particles of the matter show continuous random movements. The spreading of ink in a beaker of glass, the smell that comes from *agarbattis*, etc. are few illustrations that show the movement of particles of a substance. When the particles of two different types of matters intermix on their own, the phenomenon is called diffusion. Diffusion of particles becomes fast when the temperature is increased. A rise in temperature increases the kinetic energy of the particles, making them move more vigorously.

Particles Attract Each Other

Take an iron rod, a stick of chalk, and a pen. Try to break each one of these. Which one of these is easy to break? The iron rod is stronger than the other two items. What makes an item stronger? Yes, it's the particles in them which are held by the inter-particle force of attraction. In every substance, there is an inter-particle force of attraction acting between its particles. To break something we need to overcome this force. The strength of the force differs from one substance to another. The inter-particle force of attraction and the kinetic energy of the particles primarily determine the physical state of any matter.

Q1. What is the role of voids in solubility. How can you explain unchanged volume of solvent when solute is dissolved in it on the basis of voids? (2)

A1. Dissolved substance fits into the voids of the solvent. This makes initial and final volume of solvent to remain unchanged.

Q2. What happens to the voids when the solution is saturated. (2)

A2. All the voids are filled with solute and no vacant voids are left.

Q3. Write true or false (1x4=4)

i) Increase of temperature increases the number of voids in the solvent.

ii) Decrease of temperature increases rate of diffusion.

iii) Saturated solution becomes unsaturated when temperature is lowered.

iv) Diffusion of ink in water shows that all water particles move in one direction.

A3. i) F; ii) F; iii) F; iv) F

Q4. Name the factors determining the physical state of any matter. (2)

A4. The inter-particle force of attraction and the kinetic energy of the particles primarily determine the physical state of any matter.

3. HOLI

In the morning of Holi festival Ravi got up early. He was very much enthusiastic to play colours with his friends. He took a plastic bucket which was transparent and his water gun along with some packets of powdered water colour in the yard which is in front of his house. Each packet of colour contained 10 grams of colour. The size of bucket was 10 litres. He filled the bucket with plain water and was about to add dry packet colour when his mother shouted to not to start playing so early. In the fear of being scolded Ravi quickly dropped the colour from packet in the bucket filled with water and rushed back to his house and sat near the window from where he could keep an eye over his belongings.

While his watch over bucket and other belongings Ravi observed that the particles of powdered colour are getting dissolved in the water in the bucket on their own without being disturbed by anyone. Initially a coloured cloud like structure appeared in the bucket of water which grew up in size and finally the whole bucket of water was evenly coloured. Ravi was very much enthusiastic to observe that how come the powered colour got mixed in bucket of water so well without being stirred by anyone.

Q1. What is the density of water colour prepared by Ravi if he mixed only one packet in the bucket. Give your answer in g/cm^3. (2)

A1. Density = 1g/litre = $10^{-3} g/cm^3$.

Q2. What is name of the process observed by Ravi? How does this process depend on temperature? (2)

A. Diffusion. Rate of diffusion increases on increasing temperature.

Q3. State true and false (1x4=4)

i) Particles of liquid are always in random motion.

ii) Kinetic energy of liquid particles decreases on increasing temperature.

iii) Smell of incense stick gets distributed only in the bottom level of the closed room where it is lightened.

iv) Smell of perfume sprayed in one part of the room spreads quickly throughout the room in summer season as compared to winter.

A3. i)T; ii)F; iii)F; iv)T

Q4. How many buckets of water are required to be mixed with the coloured bucket to make the solution colourless. What does the result signifies. (2)

A4. Infinite. Particles of matter are extremely small in size.

4. Evaporation

Evaporation takes place all around us, always and everywhere. Science has been studying it more carefully for more than 120 years and so far we have all been convinced that we have a good understanding of this phenomenon. However, when we look into the details of the process of evaporation, we suddenly see how much we have missed.

Seemingly, we already know everything there is to know about evaporation. However, we've had another surprise: it turns out that small drops are stragglers and they evaporate more slowly than their larger counterparts, according to physicists from the Warsaw Institutes of the Polish Academy of Sciences.

When a gas molecule approaches a liquid surface at a distance of several to a dozen or so mean free paths, it virtually stops colliding with other molecules in its environment. At this point, a typical description of the phenomenon by means of thermodynamics is no longer sufficient. Near the surface of the liquid, energy transport takes place in a different manner, ballistically. The gas molecule simply takes its energy and hits the surface, sometimes several times.

If the drop is large, its surface from the point of view of the gas molecule will be practically flat. Therefore, when such a molecule bounces off the surface, it can collide with another nearby gas molecule and hit the surface again, depositing another portion of energy into it. The situation changes when the drop decreases in size and its surface becomes more and more curved. The particle then bounces off the surface generally once, after which it flies off into space. The transfer of energy to the interior of the liquid is thus less effective. As a result, the drops evaporate more slowly the smaller they are, and the process can be slowed down at least several times.

Q1. What do you mean by straggler. Who is termed as straggler in which group? Why is it so? (2)

A1. Someone in a group which becomes separated from the others in some manner. Small liquid drop is considered as straggler in a group of liquid drops. It is so because it evaporate more slowly as compared to their larger counterparts.

Q2. Write true of false (1x4=4)

i) Evaporation takes place at a particular temperature.

ii) Surface exposure has no role in evaporation.

iii) Evaporation decreases on increasing humidity.

iv) Process of evaporation brings about cooling effect.

A. i)F; ii)F; iii)T; iv)T

Q3. Which phenomenon can not merely be described by means of thermodynamics. What else is required to be considered? (2)

A3. Evaporation. Ballistic collision of gas molecules with liquid molecules and energy transfer between them must be considered.

Q4. What do you mean by distance of several to a dozen or so mean free paths? (2)

A4. The distance under consideration is several times of the distance of mean free path or it is almost 12 times of the distance of mean free path.

5. SOLUBILITY

Rekha and Harish were newly married. Rekha's father is a government contractor and is very rich. Before marriage Rekha enjoyed all sort of lavishness, she never washed clothes never done any cooking and there were many things to which she was new. One day Harish asked her to make a lemonade for him. Although Rekha never went to kitchen yet she had an idea that to make a lemonade all she needed is a lemon, water sugar and ice and she knew that all these things are required to be mixed well.

Being new to the kitchen she added ice to the water first and then started dissolving sugar crystal to the cold water. Contrary to her thought she found it very difficult to dissolve sugar crystals to cold water where as she had observed her mother to dissolve sugar crystals in water very easily. She was unable to find what the problem is.

Q1. Why Rekha was unable to dissolve sugar in water as easily as her mother? (2)

A1. She added ice to the water first which makes dissolving of sugar difficult.

Q2. What had she done to make the process easy? (2)

A2. She should have dissolved sugar in water first and later on added ice to it.

Q3. What is the effect of temperature on solubility? (2)

A3. Solubility increases on increasing temperature.

Q4. What is saturated solution? (2)

A4. If we go on adding solute to the solvent then after some stage solute stops dissolving in the solvent. At this stage solution is said to be saturated.

Q5. How can a solution be made unsaturated by changing temperature? (2)

A5. If temperature is increased saturated solution becomes unsaturated and allows mixing of more solute to the solvent.

PERIODIC CLASSIFICATION OF ELEMENTS

1. DOBEREINER'S TRIADS

According to Dobereiner, all elements occurred in groups of three, when arranged in increasing order of atomic masses. He referred to these groups as triads. In a triad the elements had similar chemical properties.

Triads of the Dobereiners classification:

Triad1:

Element	Atomic mass
Lithium (Li)	7
Sodium (Na)	23
Potassium (K)	39

Triad2:

Element	Atomic mass
Chlorine (Cl)	35.5
Bromine (Br)	80
Iodine (I)	127

Triad3:

Element	Atomic mass
Calcium (Ca)	40
Strontium (Sr)	88
Barium (Ba)	137

Dobereiner's law of triads states that, the atomic mass of the middle element of a triad is the arithmetic mean of the atomic masses of the other two elements. Example: In the triad of lithium, sodium and potassium. The atomic mass of lithium is 7 and the atomic mass of potassium is 39. The average of masses of lithium and potassium gives atomic mass of sodium 23.

Drawbacks: All the known elements could not be arranged in the form of triads.

This law did not hold good for elements with very low or very high atomic mass.

Example: The arithmetic mean of the atomic masses of fluorine 19 and bromine 80, which comes to 49.5, varies significantly from the atomic mass of chlorine, which is 35.5.

Q1. What do you mean by triad.

A1. Any group consisting of three elements or objects is known as triad. (2)

Q2. If three consecutive elements of Dobereiner's triad have atomic mass x,y,z then what is the relation between x,y and z? (2)

A2. y=(x+z)/2 or 2y=x+z.

Q3. Does every known element had its unique place in Dobereiner's triad? (2)

A3. No Dobereiner's triad does not cover each and every element.

Q4. What is the basis of arranging elements in Dobereiner's triad? (2)

A4. The elements in the triads exhibit same chemical property according to Dobereiner.

Q5. Mention any two criteria for rejection of Dobereiner's triad? (2)

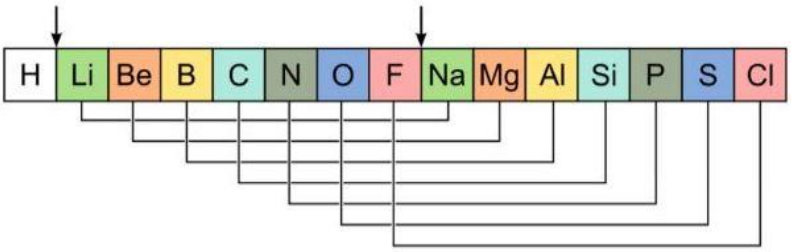
A5. Criteria for rejection

i)All the known elements could not be arranged in the form of triads.
ii) This law did not hold good for elements with very low or very high atomic mass.

2. Newland's Law of Octaves

In the year 1864, the British chemist John Newlands attempted to arrange the 56 elements known at that time. He arranged them in an ascending order based on their atomic masses and observed that every 8th element had similar properties. On the basis of this observation, Newland's law of octaves was formulated.

The **law of octaves** states that every eighth element has similar properties when the elements are arranged in the increasing order of their atomic masses. An illustration detailing the elements holding similar properties as per Newland's law of octaves is provided below.



Newlands compared the similarity between the elements to the octaves of music, where every eighth note is comparable to the first. This was the first attempt at assigning an atomic number to each element. However, this method of classifying elements was met with a lot of resistance in the scientific community.

Limitations of Newland's Law of Octaves

The key shortcomings of Newland's law of octaves are listed below.

- Several elements were fit into the same slots in Newland's periodic classification. For example, cobalt and nickel were placed in the same slot.
- Elements with dissimilar properties were grouped together. For example, the halogens were grouped with some metals such as cobalt, nickel, and platinum.
- Newland's law of octaves held true only for elements up to calcium. Elements with greater atomic masses could not be accommodated into octaves.
- The elements that were discovered later could not be fit into the octave pattern. Therefore, this method of classifying elements did not leave any room for the discovery of new elements.

Q1. What are octaves? (2)

A1. Octaves are similar sounding notes in the music. Two consecutive octaves are separated by 7 notes.

Q2. Why Newland compared the elements to the octaves? (2)

A2. As in music octaves sound similar to each other, in the same manner when the elements are arranged in the increasing order of their atomic masses then every eighth element has similar properties.

Q3. According to Newland's law of octaves hydrogen is similar in properties to which two elements shown in the figure?

A3. Fluorine (F) and Chlorine (Cl).

Q4. Will the elements discovered after Newland can fit into the octave pattern?

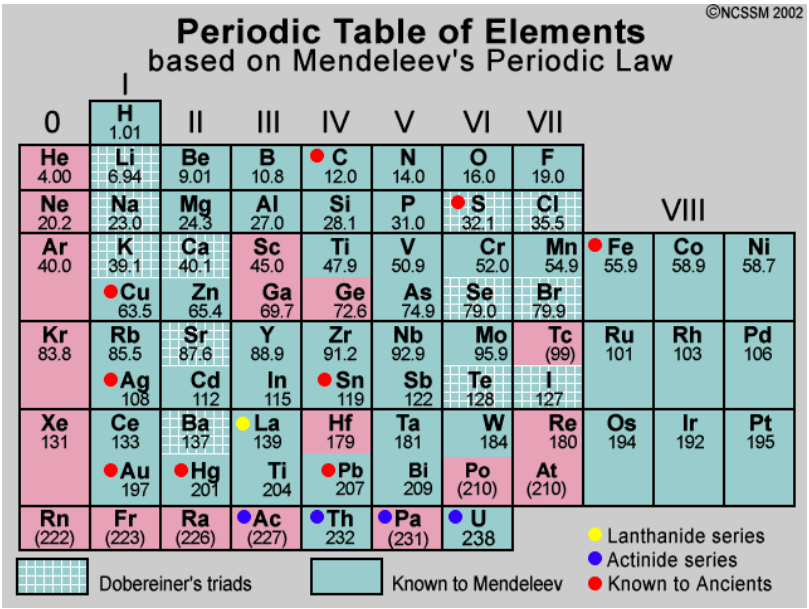
A4. No. Elements having mass number greater than calcium do not follow to Newland's law of octaves.

Q5. This law holds good up to which element?

A5. Calcium.

3. Mendeleev's Periodic Table

In 1869, just five years after John Newlands put forward his Law of Octaves, a Russian chemist called Dmitri Mendeleev published a periodic table. Mendeleev also arranged the elements known at the time in order of relative atomic mass, but he did some other things that made his table much more successful.



Mendeleev realized that the physical and chemical properties of elements were related to their atomic mass in a 'periodic' way, and arranged them so that groups of elements with similar properties fell into vertical columns in his table.

Sometimes this method of arranging elements meant there were gaps in his horizontal rows or 'periods'. But instead of seeing this as a problem, Mendeleev thought it simply meant that the elements which belonged in the gaps had not yet been discovered. He was also able to work out the atomic mass of the missing elements, and so predict their properties. And when they were discovered, Mendeleev turned out to be right. For example, he predicted the properties of an undiscovered element that should fit below aluminium in his table. When this element, called gallium, was discovered in 1875 its properties were found to be close to Mendeleev's predictions. Two other predicted elements were later discovered, lending further credit to Mendeleev's table.

Modern day periodic tables are expanded beyond Mendeleev's initial 63 elements. Most of the current periodic tables include 108 or 109 elements. It is also important to notice how the modern periodic table is arranged. Although we have retained the format of rows and columns, which reflects a natural order, the rows of today's tables show elements in the order of Mendeleev's columns. In other words the elements of what we now call a 'period' were listed vertically by Mendeleev. Chemical 'groups' are now shown vertically in contrast to their horizontal format in Mendeleev's table. (reference)

Q1. Fill in the blanks (1x4=4)

i) According to Mendeleev periodic elements with same properties are arranged in ……. columns.

ii) …….. number of elements were later discovered which successfully fit in the gap of Mendeleev's periodic table.

iii) Properties of …… were already predicted by Mendeleev whereas it was discovered in 1875, almost four years after the construction of Mendeleev periodic table.

iv) In modern periodic table the rows and columns of Mendeleev periodic table have been ……..

A1. i)vertical; ii)three; iii) gallium; iv)interchanged

Q2. Give one basic difference between Mendeleev periodic table and modern periodic table. (2)

A2. In modern periodic table periodic elements are arranged horizontally whereas in Mendeleev periodic table they were arranged vertically.

or In modern periodic table chemical groups are arranged vertically whereas in Mendeleev periodic table they were arranged horizontally.

Q3. How Mendeleev's positive attitude is exhibited from above reference? (2)

A3. Sometimes the method of arranging elements in Mendeleev periodic table left gaps in his horizontal rows or 'periods'. But instead of seeing this as a problem, Mendeleev thought it simply meant that the elements which belonged in the gaps had not yet been discovered. He was also able to work out the atomic mass of the missing elements, and so predict their properties. When they were discovered, Mendeleev turned out to be right.

Q4. How many more elements were further added to modern periodic table after Mendeleev? (2)

A4. Modern day periodic tables are expanded beyond Mendeleev's initial 63 elements. Most of the current periodic tables include 108 or 109 elements i.e. 45 to 46 elements were discovered later on.

4. Features of Modern Periodic Table

The elements of group 1, 2, 13, 14, 15, 16, and 17 are known as the main group elements or normal elements. The elements of groups 3, 4, 5, 6, 7, 8, 9, 11 and 12 are known as the transition elements. Group 18 is called noble gases or inert gases. Their outermost shell is completely filled. Due to this stable electronic configuration, they generally don't react with the other elements.

When we talk about the periods of a modern periodic table, one should keep in mind that the number of shells present in an atom determines its period number. The elements of period one will have only one shell, elements of period two will have two shells and so on. The first period of the modern periodic table is the shortest period as it contains only two elements. The period number two and three consists of eight elements each and is known as short groups. Period four and five have eighteen elements and are known as the long group. In the modern periodic table, group number 3 of period six contains the lanthanide series which are the rare earth elements. We have radioactive elements (actinides) present in group 3 of period seven.

Q1. How many shells are there in an element belonging to fourth period. (2)
A1. 4 shells.
Q2. Elements which are unstable belong to which group and which period? (2)
A2. Group III, Period VII.
Q3. Why Nobel gases are said so? (2)
A3. Nobel gases are inert their outer most orbit is having 8 electrons and hence completely filled due to which they do not react with any other element. Due to their non reactive nature they are termed as nobel.

Q4. Which is the shortest period in modern periodic table and how many elements are there in it? (2)
A4. I period , 2 elements
Q5. Which two periods are long groups and how many elements are there in the two groups combined? (2)
A5. Group IV and Group V. In all they have 36 elements.

5. Classification of Elements in Modern Periodic Table

There are eighteen vertical columns known as groups in the modern periodic table which are arranged from left to right and seven horizontal rows which are known as periods.

Group number	**Group name**	**Property**
Group 1 or IA	Alkali metals	They form strong alkalis with water
Group 2 or IIA	Alkaline earth metals	They also form alkalis but weaker than group 1 elements
Group 13 or IIIA	Boron family	Boron is the first member of this family
Group 14 or IVA	Carbon family	Carbon is the first member of this property
Group 15 or VA	Nitrogen family	This group has non-metals and metalloids
Group 16 or VIA	Oxygen family	They are also known as chalcogens
Group 17 or VIIA	Halogen family	The elements of this group form salts.
Group 18	Zero group	They are noble gases and under normal conditions they are inert.

Group→ / ↓Period	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																		2 He
2	3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca		21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr		39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	* *	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
			*	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb		
			* *	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No		

Q1.What do we obtain when we react alkali metals with water? (2)

A1. Strong alkali.

Q2.What is the difference in the alkali obtained after reacting water with Group I and that with Group II. (2)

A2. Stronger alkalis are obtained with Group I as compared to Group II.

Q3. What is the basis of arranging elements in modern periodic table? (2)

A3. Atomic number.

Q4. What is the atomic number of last element in Halogen Family? (2)

A4. 117.

Q5. Which is the only liquid metal existing at room temperature? In which group and period does it lie? (2)

A5. Mercury. Group 12 and Period 6.

END