Name: _____ Admission No: Class:

millennia institute

2015 Preliminary Examination 2
Pre-University 3

GEOGRAPHY (HIGHER 2) **9730/01**
Paper 1 Physical Geography **15 September 2015**

Answer Scheme

Lithospheric Processes, Hazards and Management

1 Photograph A shows a mass movement that took place in a humid temperate climatic zone.

(a) With reference to Photograph A, identify the mass movement and describe its main features. [3]

The mass movement is slumping, which refers to materials moving rotationally over a curved slide plane [reserve 1m]. There is an accumulation of a bulge of debris at the toe (far end of the slide) [1]. A linear tongue of material is left behind [1]. There is an exposed scar which is the curved sliding plane on which the materials moved [1].

(b) With reference to Photograph A, briefly explain the mass movement process you have identified in (a). [3]

Slumping is a form of landslide that is often associated with times of heavy rainfall, where the sudden influx of water into the slope system de-stabilises the slope [1]. The increased water content raises fluid pressure within the pore spaces causing the loss of grain-to-grain contact and thus frictional resistance [1]. In addition, the addition of water makes the slope materials heavier, and thus subject to greater gravitational pull [1].

(c) Besides climate, explain other factors that might have contributed to the mass movement process. [6]

- *Rock Type*

Rocks which are weak in structure, that is, very well jointed, with well-connect vertical and horizontal joints or bedding planes, are more susceptible to breakage caused by frost penetration, resulting in reduction in shear strength [1]. In addition, areas where the bedding of the rock dip towards the slopes are prone to mass movement because shear strength is weakened by the downward dip of the bedding plane, which can serve as a slide plane for detached slabs of rocks, particularly when rainwater lubricates the surface to further reduce shear strength [1]. In contrast, slopes with reverse dipping beds are more likely to be stable.

- *Hydrology of the area*

The hydrology of an area refers to the input and nature of water flow. The amount of rainfall is important. When regolith or the weathered layer is saturated by heavy rains, it reduces the grain to grain contact between the soil particles and this reduces the angle of repose of the slope and lowers shear strength, thus triggering a mass-wasting event [1]. Rocks can also be saturated by heavy rains and this increases its weight and the shear stress of the material, making it more prone to mass wasting [1]. In addition, in some places, during spring, snowmelt infiltrates into the soil, increasing its mass. This increases the shear stress and reduces the shear strength of the material because water changes the consistency of the material. This leads to mass wasting as well [1]. Lastly, groundwater may dissolve minerals that cement a mass together, resulting in a loss of shear strength because water reduce the cohesion a block of material has with the underlying strata [1].

- *Plate Movements and Earthquakes*

Generally, when seismic waves pass through a mass of unconsolidated materials, the particles tend to move differentially. This breaks the inter-granular bonds formed by minerals like clay and ice. As such, the shear strength of a material can be drastically reduced, causing sudden slope failure [1]. For example, at convergent boundaries, mountains building processes and formation or eruption of volcanoes are accompanied by earthquakes, which in turn act as triggers for mass wasting events due to the loss of grain to grain contact, and lowers shear strength [1]. It can also cause snow to melt or empty crater lakes, which rapidly release large amounts of water that can be mixed with regolith to reduce grain to grain contact, to result in the landslide above [1].

- *Human activities*

Human actions such as slope modification changes the slope angle so that it is no longer at the angle of repose [1]. Examples of such slope modification include undermining the slope by excavation for a building site, road or pipe, results in lowering of shear strength and adding of shear stress [1]. Deforestation by human actions removes the binding effects of soil provided by trees, which destabilizes slopes and cause slope to reduce in shear strength, and hence increasing probability of mass movement.

[3 factors @2m each, or 2 factors @3m each]

Atmospheric Processes, Hazards and Management

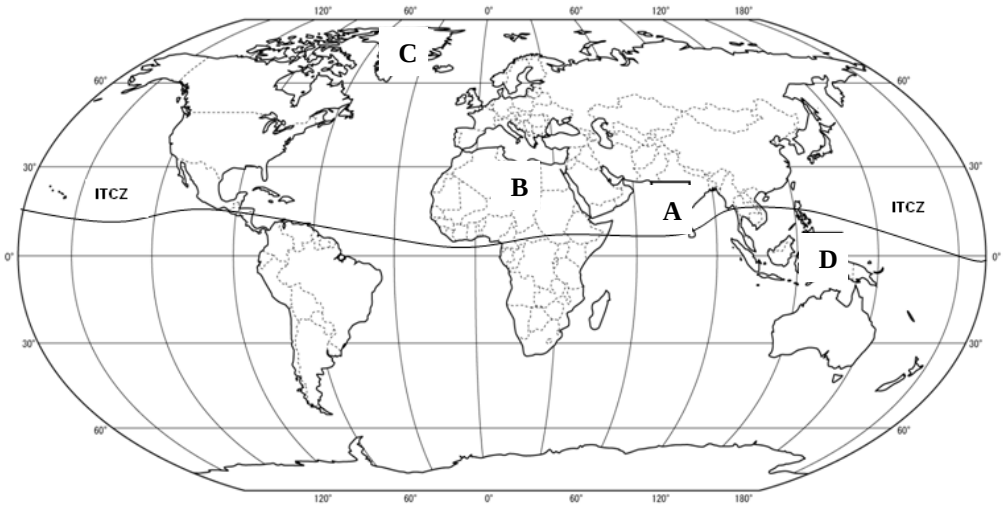
2 Table 1 shows the climatic characteristics of certain climatic zones. Fig. 1 shows the earth's energy budget. Fig. 2 shows the world map.

(a) Study the climatic characteristics in Table 1. Fill in the alphabets into the boxes to match the correct climatic characteristics to the four areas as shown in Fig. 2. [4]

Answer:

Fig. 1 for Question 2

The world's climate



(b) With reference to Fig. 1, explain the various pathways in which radiation travels within the earth's atmosphere. [4]

Suggested answer:

Solar radiation passing through the atmosphere to the Earth's surface will go through three atmospheric processes. These processes act on the radiation when it interacts with gases and suspended particles found in the atmosphere. The process of scattering occurs when small particles and gas molecules diffuse part of the incoming solar radiation in random directions without any alteration to the wavelength of the electromagnetic energy. Scattering does, however, reduce the amount of incoming radiation reaching the Earth's surface. A significant proportion of scattered shortwave solar radiation is redirected back to space. In Fig. 1, the radiated solar radiation radiated back to space amounts to about 6%. **[1m]**

Additional Information: The amount of scattering that takes place is dependent on two factors: 1) wavelength of the incoming radiation and 2) the size of the scattering particle or gas molecule. In the Earth's atmosphere, the presence of a large number of particles with a size of about 0.5 microns results in shorter wavelengths being preferentially scattered. This factor also causes our sky to look blue because this color corresponds to those wavelengths that are best diffused. If scattering did not occur in our atmosphere the daylight sky would be black.

When intercepted, some gases and particles in the atmosphere have the ability to absorb incoming insolation (Fig. 1). Absorption is defined as a process in which

solar radiation is retained by a substance and converted into heat energy. The creation of heat energy also causes the substance to emit its own radiation. In Fig. 1, it shows that absorption can occur in the atmosphere level (16%) or absorbed by the clouds (3%). **[1m]**

Additional Information: In general, the absorption of solar radiation by substances in the Earth's atmosphere results in temperatures that get no higher than 1800° Celsius. According to Wien's Law, bodies with temperatures at this level or lower would emit their radiation in the longwave band. Further, this emission of radiation is in all directions so a sizable proportion of this energy is lost to space.

The final process in the atmosphere that modifies incoming solar radiation is reflection. Reflection is a process where sunlight is redirect by 180° after it strikes an atmospheric particle. This redirection causes a 100% loss of the insolation. Most of the reflection in the atmosphere occurs in clouds when light is intercepted by particles of liquid and frozen water. The reflectivity of a cloud is shown to be around 20% in Fig. 1. **[1m]**

[1m will be given for referring to the statistics given in Fig. 1]

(c) State and explain two factors that can determine the heat budget of an area. [4]

Suggested answer:

List of factors:

1. Latitude
2. Altitude
3. Length of Day and Night
4. Seasonal changes

At lower latitudes, the sun's rays pass through shorter distance of the atmosphere before reaching the earth's surface as compared to the higher latitudes (refer to Figure 2.1).

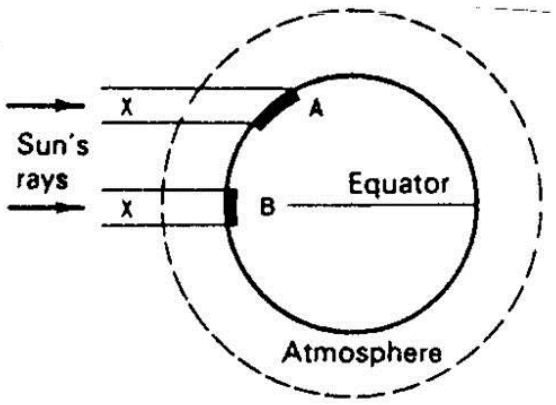


Figure 2.1: Latitude affects the distance of the atmosphere that the sun's rays pass through

As such, there is less energy loss through processes of absorption or reflection by dust particles and water vapour in the atmosphere, allowing for more insolation to reach the earth's surface.

Insolation is received during daylight hours, reaching its peak at noon. Hence, where length of day and night varies, there will be a resultant variation in temperature. Taking for instance, in an equatorial region the temperature variation throughout the year is relatively constant as there is no seasonal variation in temperature, the day and night are of equal length throughout the year

[2 marks will be awarded for each well explained factor]

Hydrologic Processes, Hazards and Management

3 Fig. 3 shows the storage and movement of water between the biosphere, atmosphere, lithosphere, and the hydrosphere.

(a) With reference to Fig. 3, identify and explain two factors that can influence the amount of river discharge. [4]

Suggested Answer:

Students may select any of the following 2 factors to explain. Please take note that when the infiltration increases, discharge will be reduced, and vice versa.

Rock and soil type
· Permeable rocks ad soils (such as sandy soils) absorb water easily, so surface run-off is rare
· Impermeable rock and soils (such as clay soils) are more closely packed. Rainwater can't infiltrate, so water reaches the river more quickly
· Pervious rocks (like limestone) allow water to pass through joints, and porous rocks (like chalk) have spaces between the rock particles

Land use
· In urban areas, surfaces like roads are impermeable – water can't soak into the ground. Instead, it runs into drains, gathers speed and joins rainwater from other drains – eventually spilling into the river
·In rural areas, ploughing up and down (instead of across) hillsides creates channels which allow rainwater to reach rivers faster increasing discharge
· Deforestation means less interception, so rain reaches the ground faster. The ground is likely to become saturated and surface run-off will increase

Rainfall
· The amount and type of rainfall will affect a river's discharge
· Antecedent rainfall is rain that has already happened. It can mean that the ground has become saturated. Further rain will then flow as surface run-off towards the river
· Heavy continual rain, or melting snow, means more water flowing into the river

Relief
· Steep slopes mean that rainwater is likely to run straight over the surface before it can infiltrate. On more gentle slopes infiltration is more likely. Hence, this will reduce the river discharge. However, it will ensure a continuation of discharge in the river throughout the year.

Weather conditions
· Hot dry weather can bake the soil, so that when it rains the water can't soak in. Instead, it will run off the surface, straight into the river.
·High temperatures increase evaporation rates from water surfaces, and

transpiration from plants – reducing discharge
· Long periods of extreme cold weather can lead to frozen ground, so that water can't soak in.

(b) Describe and explain the necessary steps needed to investigate the velocity of a section of a river channel. [8]

Suggested Answer:

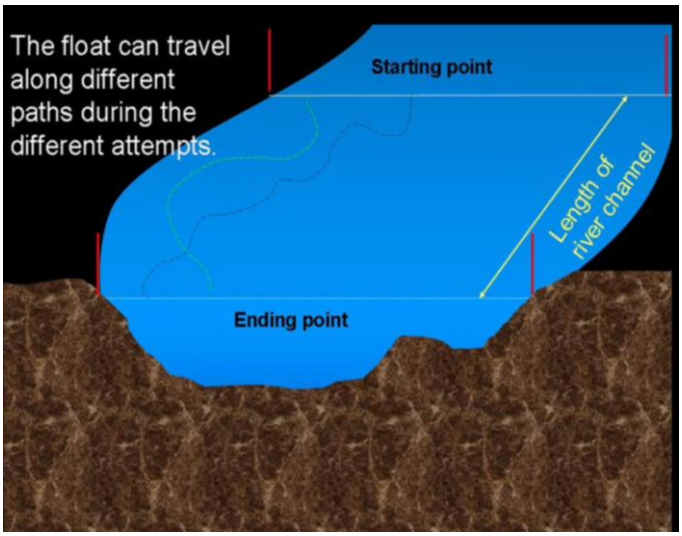


Fig. 3.1: Methods taken to find velocity of a river section

Measure out a length of the river area you are investigating. Try to measure right along the section which interests you. If you want the velocity of a riffle, try to use the whole riffle, not just a part of it. A distance of 10m is usually quite long enough and also keeps the maths quite easy **[2m]**.

Get somebody to wade out into the river, or carefully hang over it if it's too dangerous or deep, at the upstream end of your measured section. It will be their job to release the float. It is important that they are able to just release it without throwing or pushing it, because it should start from rest. Throwing it in from the bank will give it extra speed and ruin your results. If you want to re-use the float you will need someone else at the downstream end to recover it too. An even better way to do this is to release the float just a little way upstream of the starting point. This allows the float to get up speed and be moving at the speed of the river when it reaches the start point, rather than starting from stationary. **[2m]**

A person with a watch which can record in seconds (or tenths of seconds) tells the upstream person to release the float and begins timing it. They stop timing when it reaches the end of the measured section. Then take down the timings.

Repeat the experiment three or more times if possible. The float will get caught in different currents and, perhaps, behind different obstacles every time. By averaging several different reading a better result can be obtained. **[2m]**

In order to calculate the velocity, let's assume that measurements were taken four times over a distance of 10m. And the results were:

First time 28 seconds
Second time 34 seconds
Third time 36 seconds
Fourth time 30 seconds

To find the average time we need to add the times together and divide by the number of readings:

Average = (28+34+36+30) / 4 = 32 seconds

Now that we have an average time of 32 seconds we can work out the velocity of the river in meters per second. The float travelled 10m in 32 seconds, so to find the time to travel 1m, we divide the distance travelled by the time taken:

Distance / Time = 10/32 = 0.3125

So we have a surface velocity of 0.3125 meters per second. **[2m]**

Additional information:

The velocity of a river is the speed at which water flows along it. The velocity will change along the course of any river, and is determined by factors such as the gradient (how steeply the river is losing height), the volume of water, the shape of the river channel and the amount of friction created by the bed, rocks and plants.

Equipment

Velocity can be measured using very simple equipment. A watch capable of timing in seconds, something to float on the water and a tape measure are all that is required to find the velocity of the water surface.

All about Floats

When measuring the velocity on the surface of the water it is common to time how long a float takes to travel a set distance. If you know how far it travelled and how long it took, you can find it's velocity.

There are certain things to look for in a float, apart from the obvious fact that it has to be able to float!

Firstly, you must be able to see it. Bright colours are much better than dull ones; transparent floats are **not** a good idea.

Secondly, it must be able to withstand some rough treatment, especially in fast flowing and turbulent water.

Thirdly, it must not catch the wind. Only the water should be able to move it. A paper boat or any other float that sticks well out of the water can be blown by the wind and won't give reliable readings.

It is possible to buy special floats that are bright, strong and which float almost submerged, but they are expensive and you are likely to lose a few every time you do some fieldwork. The good news, however, is that an Orange makes an excellent float, it's a bright colour, quite strong and it floats almost submerged so the wind doesn't blow it along.

Atmospheric and Hydrologic Processes, Hazards and Management

4 Fig. 4A shows the spatial distribution of wet and dry areas globally. Fig. 4B shows changes in soil and vegetation profiles, as well as climatic characteristics, in Eastern Europe.

(a) **i)** Describe the distribution of dry areas as shown in Fig. 4A. [2]

Suggested Answer:

Dry areas are located in North Africa; Southwest of South Africa; Western and Central Australia; Southwest of North America; Western and Northern Asia; and the western coast of South America.

i) Demonstrate how air circulation affects the distribution described above. [5]

Suggested Answer:

Apart from the western coast of South America, the other dry areas are located at high pressure belts known as horse latitudes (30° N and S) where air sinks and warm adiabatically. **[1m]**

Air sinking at horse latitudes forms the sinking limbs of Hadley cells, a circulation that charts the vertical movement of air parcels and its consequential pressure on the earth's surface. **[1m]**

At the equatorial latitudes, intense solar heating causes warm air to rise, producing a region of relatively low atmospheric pressure at the earth's surface. The warm air rises until it reaches the upper troposphere when it starts to cool. The air then spreads north and south towards the poles at 30° N and S. **[1m]**

Once the air reaches latitudes of about 30° N and S, it starts to descend (because colder air is heavier). The descending air creates a high atmospheric pressure at the earth's surface (subtropical high pressure belts). This descend warms the air parcels adiabatically. **[1m]** Hence, the subtropical climate is associated with generally clear skies, low rainfall and high daytime temperatures exceeding 40°C. Therefore, many of the world's dry areas such as deserts are found in this subtropical high pressure belt. **[1m]**

(b) Describe and account for the variations in ground water table through Eastern Europe as shown in Fig. 4B. [7]

Suggested Answer:

Water table increases in depth, with the shallowest (or near surface) occurring in deserts and the deepest in tundra. **[1m]** The nature of vegetation and the presence of top soil affect the downward migration (infiltration) of water and consequently on the varied depth of water table across Eastern Europe.

Extremely cold climates does not allow for trees to grow in tundra. Vegetation is limited to mosses, lichens and shrubs. Hence, water loss via transpiration is limited. Because of prolonged extreme low temperatures, permafrost – which is permanently frozen soil, is formed. This prevents the loss of subsurface water as temperatures are low and evaporation is zero. **[2m]**

In contrast, the presence of top soil layer such as in deciduous areas showed that biotic weathering is relatively dominant and surface erosion is minimised (to allow for the accumulation of weathered rocks and soil). The presence of trees encouraged the downward infiltration of rainwater through passages created by the tree roots system. This account for the deep water table in deciduous areas. **[2m]**

Gypsum is a mineral commonly found in sedimentary rocks and its presence in soil greatly increased infiltration of water and reduces surface runoff. In addition, bedding planes and joints are present in sedimentary rocks and these provided pathways for water to migrate downwards (high permeability), contributing to the water table. **[2m]**

Note: Because of the presence of gypsum in desert, water table is shallow here due to the evaporation rates are high in desert due to high temperatures. High potential evaporation rates are due to the lack of water in desert.

Section B

Answer **two** questions, each from a different topic.
All questions carry 25 marks each.

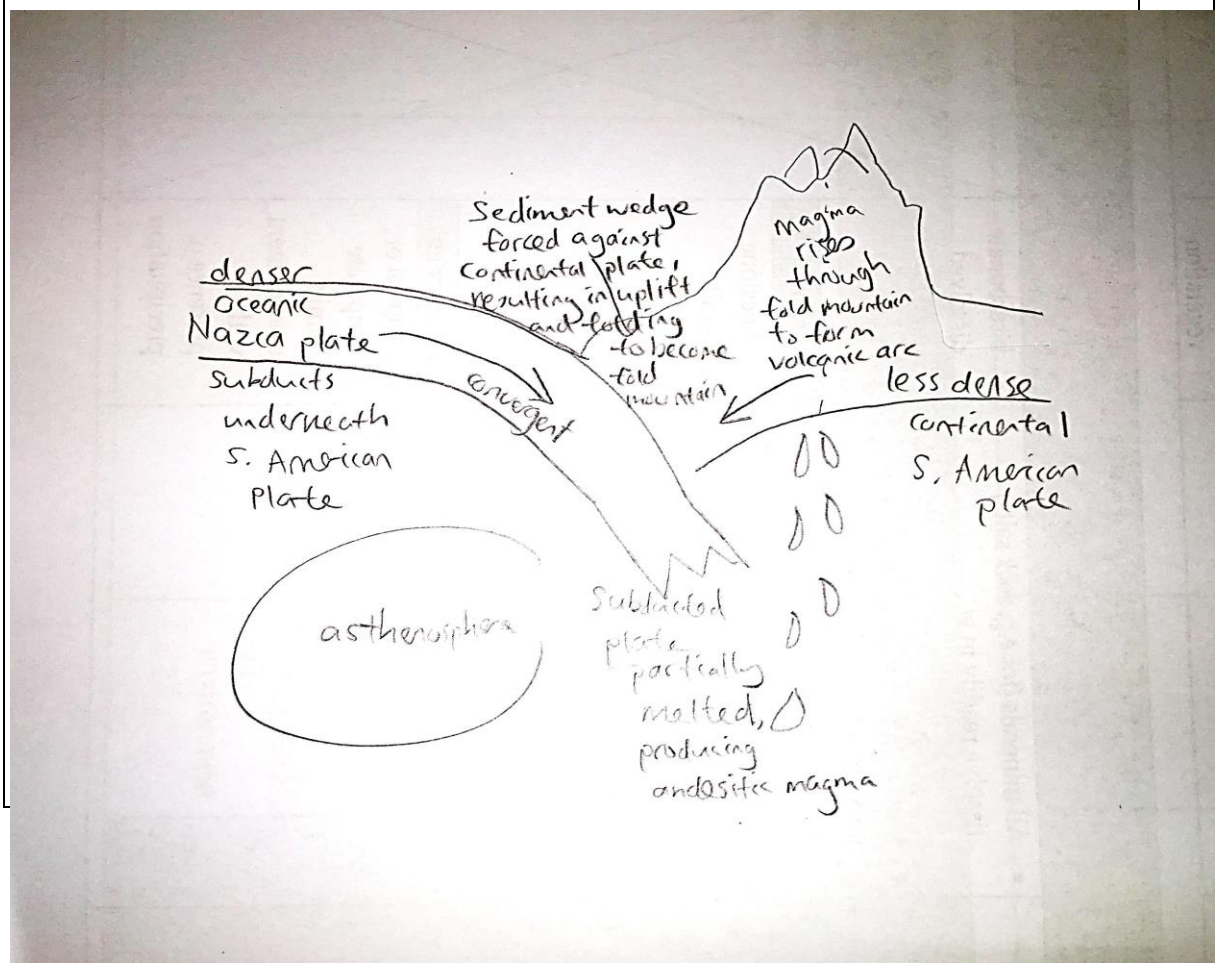
Lithospheric Processes, Hazards and Management

5 EITHER

(a) With the aid of diagram(s), describe and account for the nature and location of volcanic arcs. [9]

Suggested Answer:

3m for well-annotated diagram(s)	***3m***



P: Volcanic arcs are usually located at convergent boundaries between oceanic plates and continental plates, such as between Nazca Plate and South American Plate. It can also be found at convergent boundaries between oceanic Juan de Fuca Plate and continental North American Plate. **EE:** This is the location where oceanic plates such as Nazca Plate and continental plates such as South America Plate collide. Due to contrast in densities, the denser oceanic plate subducts underneath the less dense continental plate. At the same time sediment wedge adjacent to the continental mass is forced directly against the leading edge of the continental crust, and the subducting oceanic plate will be forced down steeply into the asthenosphere where the plate will be partially melted As the descending plate dives into the aesthenosphere, it melts and produces magma. Also at the same time, due to the convergence of the two plates, the sediment wedge pushed up to form fold mountains. The magma then rises from the continental crust and fold mountains to form volcanic arc or volcanoes on fold mountain range. **L:** Therefore volcanic arcs are located at convergent plate boundaries between oceanic and continental plates.	**3m**
P: Volcanic arcs are usually explosive in nature and produces pyroclastic materials and tall columns of ash clouds. **EE:** The volcanoes are explosive in nature due to the nature of the magma. As the oceanic plate suducts underneath the continental plates, andesitic magma is produced from the partial melting in the subduction zone. The andesitic magma, being viscous in nature, would trap air bubbles easily. As the magma rise up cracks in the continental plate, the sudden release of pressure results in explosive stratovolcanoes on the fold mountains. The explosive volcanoes produce much pyroclastic materials that are deposited in the mountain areas. The explosive volcanoes frequently form calderas where they develop from eruptions from large, shallow magma chambers. **L:** The nature of volcanic arcs is thus determined by the magma produced when the plates involved collide.	**3m**

(b) With reference to examples, describe the effects of volcanic eruption on the natural and human environment.

Assess the measures taken to manage these effects. [16]

Suggested Answer:

Introduction

Volcanic eruption is a natural phenomenon whereby magma ejects from the earth's crust as lava, bringing along with it volcanic ash, pyroclastic materials, especially along subduction zones. However, volcanic eruptions become hazardous when humans are exposed to these hazards. Volcanic activities, especially large-scale ones, may last only a few days, but the massive outpouring of gases and ash can influence climate patterns for years. Volcanic hazards, be it primary or secondary ones, can also have short term as well as lasting impacts on the human environment. However, given the land-scarce nature of the earth, as well as the ever-increasing human population, it is important to manage the impacts in order for human to live with the hazards. This essay looks at some of the impacts on the physical and human environment, as well as some mitigation measures to manage these impacts.

P: Volcanic hazards have atmospheric impacts on the natural environment, such as the lowering of global temperatures.

EE: These effects result primarily from the ejection of ash and extremely fine particles or droplets known as aerosols high into the stratosphere during major eruptions. Some eruption columns reach such great heights that high-level winds transport fine debris and sulphur-rich gas around the world. The aerosols increase the reflection of radiation from the sun back into space and thus, cool the Earth's lower atmosphere or troposphere. For instance, the 1991 eruption of Mount Pinatubo blasted more than 8km of fine pyroclastic material and sulphur-rich gas high into the atmosphere, causing significant global cooling for as long as two years. In some instances, volcanic eruptions can result in temporary warming of the earth's atmosphere as well. When large amounts of water and carbon dioxide in the form of gases are released into the atmosphere, they absorb heat radiation emitted by the ground and hold it in the atmosphere. This causes the air below to get warmer. For instance, recent eruptions such as Mount St. Helens, Washington (1980), El Chichon, Mexico (1982) and Mount Pinatubo, the Philippines (1991) clearly show the importance of sulphur aerosols in modifying climate, warming the stratosphere and cooling the troposphere.

L: Therefore, a major eruption may cause a localised temporary warming of the atmosphere instead of cooling.

P: Volcanic hazards have negative effects on the human environment as well. For instance, lahars can be resulted from volcanic eruption which causes damage to the human environment.

EE: Lahars are hot or cold mixture of water and rock fragments flowing down the slopes of a volcano. In 1985, Columbia, Nevado Del Ruiz erupted, and pumice and meltwater produced by the hot pyroclastic flows and surges swept into gullies and channels on the slopes of Ruiz as a series of lahars. Flowing downstream from Ruiz at an average speed of 60 km per hour, lahars eroded soil, loose rock debris and stripped vegetation from river channels. Within four hours of the beginning of the eruption, lahars had traveled 100 km and left behind a wake of destruction: more than 23,000 people killed, about 5,000 injured, and more than 5,000 homes destroyed along the rivers. Hardest hit was the town of Armero, in which three quarters of its 28,700 inhabitants perished.

L: Therefore, volcanic hazards in the form of lahars are another effect of volcanic eruption.

P: In order to mitigate the effects of volcanic eruptions, measures have been put in place. However, some of these measures have their merits and limitations. Some measures to manage the effects include lava flow dams, hydraulic chilling and hazard mapping.

EE: Lava flows due to eruptions destroy properties by burying cars and homes, buildings, and vegetation, as well as cutting off electric power, water, and communications. Therefore, to stop lava advance, building of diversion barriers and breaching of channel walls can be employed to redirect lava flows away from populated or valuable areas, and contain lava in dams. By building dams across a valley which is known to be a potential lava channel, then any lava from future eruptions will tend to be ponded up behind the wall. Even if the lava flow is large, it will have been held up for some time, providing sufficient time for people leaving in threatened areas below to evacuate.

L: Therefore, lava dams is effective, especially for basaltic lavas.

P: Hazard mapping has also been used to mitigate the effects of volcanic hazards, with success in some places and little success in others.

EE: A hazard-zoning map shows areas most likely to be affected by different types of volcanic activity in the future. When sufficient information about a volcano's eruptive history is available, such maps can also indicate the relative degree of hazard or the expected frequency of occurrence. Hazard maps are effective as they allow government to plan land-use on long term basis, and also allowing for effective emergency-response measures, especially when a volcano begins to show signs of unrest and the availability of such hazard maps will cumulate in issuing or urgent, timely and life-saving warnings for people to evacuate to safer grounds.

L: Therefore, hazard mapping is a very effective method, even for LDCs, to employ to mitigate against volcanic hazards.

P: However, these measures have limitations, especially for hazard mapping and lava dams.

EE: For hazard mapping, even when governments are armed with a detailed information of the history of volcanoes, scientists cannot predict how far or how much of an area each of the volcano hazards will actually extend during a future eruption, as the size of eruption, duration of eruptive activity, extent of topographic changes that occur on an erupting volcano or in nearby valleys as a result of explosive activity or new deposits, and especially the specific vent location, cannot be determined.

L: Nevertheless, despite the limitations, proper planning through the use of hazard mapping can avoid damage to property and loss of life.

P: Although lava dams have their merits, they have their limitations as well.

EE: Basically, lava dams works best for basaltic lavas, and are largely ineffective against viscous lavas, as those lavas are able to bulldoze their way and are perfectly capable of pushing over any obstacles in front of them but less viscous flows behave in a more liquid fashion and try to flow around obstacles. Hence, for areas with volcanoes that eject viscous lavas, other forms of mitigations must be taken together with lava dams to ensure more levels of protection against the hazards.

L: Nevertheless, despite the limitations, lava dam can still be built to avoid damage to property and loss of life.

Conclusion

In the final analysis, despite the limitations of the measures, it is still paramount that the measures be in place. The measures at least provide a form of protection against volcanic hazards which is able to provide confidence to the locals psychologically. Therefore, despite the shortcomings, this essay contends that the measures should still be in place.

5 OR

(a) Differentiate the formation and characteristics of sedimentary **and** metamorphic rocks. [9]

Suggested Answer:

P: Sedimentary rocks and metamorphic differ according to their formation process. **EE:** Sedimentary rocks are formed when rocks exposed to the atmosphere are unstable and subject to the processes of weathering and erosion. On the other hand, metamorphic rocks are formed when other rocks are changed by intense heat and pressure within the earth, which does not involve weathering and erosion, and burial and cementation.	**3m**
P: Metamorphic and sedimentary rocks differ in terms of their grain size. Generally, metamorphic rocks would constitute finer grain sizes while sedimentary rocks constitute varying grain sizes. **EE:** The grain size of metamorphic rocks varies in size as it is derived from the sediments which make up the sedimentary rocks. For instance, a conglomerate which is made up from the lithification of large stones and cobbles will result in the formation of large grain sized conglomerate. On the other hand, due to intense pressure during the formation of metamorphic rock, the compression and foliation will result in the rocks having fine particles.	**3m**
P: Sedimentary rocks and metamorphic rocks are vastly different in terms of their rock structure. **EE:** Sedimentary rocks are usually stratified and they occur in layers or strata and bedding planes (planes that separate one strata from another) are usually horizontal but can be folded or tilted later. However, metamorphic rocks do not have bedding planes. Instead, foliation is common in metamorphic rocks.	**3m**

(b) 'Mechanical weathering is largely responsible for block disintegration while chemical weathering is largely responsible for granular disintegration.'

To what extent do you agree with this statement? [16]

Suggested Answer:

Introduction Mechanical weathering is the breaking down of rocks without action of water and by chemical means while chemical weathering is the decomposition of rock minerals by agents such as water, oxygen, carbon dioxide and various organic acids. This essay contends that the statement about mechanical weathering is largely responsible for block disintegration while chemical weathering is largely responsible for granualr disintegration is not true as either type weathering can result in either type of outcome.
P: Mechanical weathering can be said to be largely responsible for block disintegration, especially where the processes of frost shatter is concerned. **EE:** Frost shatter refers to the repeated cycle of freezing and thawing of water in a rock joint, which widens the joint and eventually breaking down rocks in blocks. Initially, water enters the joints of rocks. During night time, when temperature drops below zero degrees Celsius, the water freezes, and its volume expands by 8-10%, causing the joint to widen.

As the water thaws during day time, the widened joint is able to allow more water to enter. The repeated cycle of freezing and thawing and exerting of stress within the rock joint causes the joint to widen further, which result in fracturing of the rock into blocks and angular pieces of rocks accumulated at the base of slopes as talus or as felsenmeer on flatter areas.

L: Therefore, mechanical weather can result in block disintegration.

P: Another mechanical weathering that leads to block disintegration is pressure release.

EE: Pressure release occur when overlying rocks are worn away and the underlying rocks such as granite or gneiss are exposed to the earth's surface. These rocks, which was formed at considerable depth and had been placed under increasingly great amount of confining pressure from above it and surrounding it, will experience internal stress within the rock mass when the pressure is released. The rock mass expands elastically and upwards and outwards, resulting in tensional stress at right angle to the earth's surface. Such expansion eventually leads to rupture and a series of cracks parallel to the surface develops. This structure is called sheet jointing, which are parallel to the land surface and form concentric shells or layers of rock up to a few metres of thickness. As the outermost shells or layers of rocks are relieved of load and expand, they break away from the parent rock beneath. Such peeling off is known as exfoliation. The outcome is the peeling off of layers of rock which contributes to block disintegration.

L: Therefore, pressure release can result in block disintegration as well.

P: Chemical weathering can be said to be largely responsible for granular disintegration. Processes such as hydrolysis and hydration can result in granular disintegration, which refers to breaking down of rocks into numerous small fragments, and affects particularly crystalline rocks, which are made up of numerous small crystals of quartz, feldspar and mica. If one type of mineral is weathered, the effect would be to loosen the structure of the rock as a whole, so that it will crumble into a mass of altered and unaltered minerals. Initially, hydrolysis occurs when water reacts with silicate minerals of rocks such as igneous and metamorphic to convert them into clay. Upon successive wet and dry cycle, the clay absorbs in more water, which then undergoes hydration. The result of clay undergoing hydration is expansion and swelling, which causes addition stress within the rock, which causes granular disintegration.

P: However, some chemical weathering processes, such as hydrolysis, is able to cause block disintegration as well.

EE: Hydrolysis involves a chemical reaction between rock minerals and water, involving the action of hydrogen (H^+) and hydroxide (OH^-) ions of the water and the ions of the mineral. Hydrolysis is the most important chemical weathering reaction of silicate minerals, hence usually affecting igneous and metamorphic rocks. For example, all feldspars hydrolyse in carbonated water to produce three end products: clay mineral (usually kaolinite), silica in solution and carbonate or bicarbonate of potassium, sodium or calcium in solution. In sum, the net result in the weathering of feldspars in granite is to leave behind residual clay minerals, notably kaolinite. Due to this, when hydrolysis takes place along joints or lines of weakness, the weakened state of the rocks causes boulders to detach from parent rocks as block disintegration.

L: Therefore, chemical weathering can result in block disintegration as well.

P: In addition, insolation, which is largely responsible for the exfoliation of rocks and therefore commonly associated with mechanical weathering, can result in granular disintegration as well.

EE: Rocks consisting of minerals of different colours and thus having varied coefficients of expansion absorb radiation and expand at different rates. The repeated expansion and contraction of the rock minerals at differing rates creates stress within the rock. Eventually, the rock surface will crumble into individual grains via granular disintegration. Also, insolation can affect crystalline rocks such as granite, where the dark-coloured minerals

such as mica absorb more heat, whereas light-coloured minerals such as quartz heat up slower.

L: As a result of alternate expansion and contraction of these minerals, the rock breaks down into small pieces through granular disintegration.

Conclusion:

Upon analysing the statement, it can be concluded that block disintegration or granular disintegration should not be tied to or confined to fixed types of weathering processes. As evident, certain mechanical processes can result in both block and granular disintegration, and the same can be said for chemical weathering processes.

Atmospheric Processes, Hazards and Management

6 EITHER

(a) Outline the methods in which climates of the past can be determined. [9]

Suggested Answer:

Introduction is not needed for 9m. But this is included in case this question is set as 16m question:

During the most recent history, scientists have been able to construct evidence of climate change from collected information on temperature, rainfall and other weather variables from past records. The reconstruction and study of past ancient climate is termed as paleoclimatology. Scientists collect indirect evidence of climate change which may respond to different conditions in the local and global environment. By combining data from various historical sources, scientists develop a broad understanding of climate change over hundreds of years for specific regions of the world. Some evidence is derived from dendrochronology, analysing oxygen isotopes in oceanic sediments, ice cores, pollen analysis and corals.

Dendrochronology

- Most trees growing in temperate areas increase trunk diameter by adding one concentric tree ring for each year of growth.
- Besides the age of trees, tree rings provide information about climate: during years of when the growing conditions are favourable (such as mild temperatures and ample precipitation), tree rings tend to be wider than in years when the growing conditions are harder.

Oxygen Isotope Analysis of Oceanic Sediments

- An isotope is one or two more forms of an element which differ from each other in atomic weight
- Ocean floor sediments provide a record of the changing oxygen isotope ration in seawater over periods of thousands of years.
- These sediments are composed of both organic and inorganic materials.
- The organic component of sea sediment includes the remnants of sea-dwelling microscopic plankton, which provide a record of past climate and oceanic circulation.
- For example, by studying the chemical composition of plankton shells, we can reveal information about past seawater temperatures, salinity (saltiness), and nutrient availability. Indeed, such techniques have been used to reconstruct ocean temperatures over the last 100 million years, and have confirmed continental drift theories of climate change that a long term global cooling has taken place since the extinction of the dinosaurs.

- By comparing the oxygen isotope ration of calcium carbonate remains in different layers of sediments in the ocean floor, scientist can determine when periods of glaciation took place.

- Similarly, the amount of oxygen isotopes in the atmosphere can give an indication of the climatic conditions during different geologic time.
- There are two isotopes in oxygen (O-16 and O-18). The O-16 isotope is slightly lighter and vaporise more rapidly
- Hence, during the warm and dry periods, evaporation of the O-16 isotopes would leave the air enriched with O-18
- When the water is freeze into polar ice, it would be preserved as a record of the climate
- Conversely, colder and wetter periods would be characterised by higher levels of O-16.

Ice Cores

- As snow accumulates on ice caps and sheets where temperatures usually remain below freezing all-year round, it lays down a record of the environmental conditions at the time of its formation. Over time, the now is compacted to ice and preserves the climatic information.
- By drilling down into glaciers, a record of snowfall going back thousands of years may be obtained in some locations. Such ice cores offer several kinds of information about past climate conditions.
- Ice cores also provide direct information about the composition of the atmosphere of
- the past.

Paleoclimate information during the Ice Age and previous warmer interglacial period (the last 120,000 years) has been obtained from ice cores by 3 main approaches.

- Analysis of the isotopic composition of the water in the ice for the reconstruction of temperature.
- Dissolved and particulate matter in the ice, and
- Physical characteristics of the ice and of air bubbles trapped in the ice, for the reconstruction of atmospheric composition.
- Ice core analysis show a close relationship between greenhouse gases concentration (especially carbon dioxide and methane) and temperatures over the past 650,000 years. Analysis of air bubbles within ice cores extracted from the Antarctica ice sheets reveals a strong correlation between reconstructed air temperatures and concentration of greenhouse gases methane and CO2.
- Lower concentrations of greenhouse gases are present during glacial episodes, while higher concentrations of greenhouse gases are present during interglacial periods.
- It has been found from the ice sheet records of both Greenland and Antarctica that during the last ice age, atmospheric CO2 levels were significantly lower than during other interglacials.
- From the chemical analysis of ice cores, it has been found that there was a gradual increase in CO2 in the Greenland ice cores from the mid-18th century and a significant increase during the last 50 years.

Pollen Analysis

- Pollen grains and spores are the basis of an important aspect of paleoclimatic reconstruction, generally referred to as pollen analysis, or palynology, the study of pollen and spores.
- When pollen and spores have accumulated over time, a record of the past vegation of an area may be preserved. In many cases, changes in the vegetation of an area may be due to changes of climate. Hence, interpreting past vegetation through pollen analysis may lead to strong inferences about the former climate of an area.
- Air-borne pollen from trees and other plants can be preserved in sediment layers on lake bottoms and in bogs.
- Cores of these sediment layers are taken and analysed for determining past climates.

Corals

- Palaeoclimate reconstruction form corals provide insights into the past variability of the tropical and sub-tropical oceans and atmosphere. The corals used for palaeoclimate reconstruction grow throughout the tropics in relatively shallow waters, often living for several centuries.
- Accurate annual age estimates are possible for most sites using a combination of annual variations in skeletal density and geochemical parameters.
- Palaeoclimate reconstructions from corals generally rely on geochemical characteristics of the coral skeleton such as temporal variations in trace elements or stable isotopes or, less frequently, on density.
- For example, corals growing near the ocean surface provide year-by-year records of tropical climates extending back over the past few centuries. As with trees, the living tissue is found only on the uppermost layer and it leaves annual growth bands.
- The relative thickness of the bands depends on ocean temperature and salinity. - Warmer water leads to rapid growth and wide, porous layers whilst cooler water leaves denser layers. However, when the water becomes too warm, the coral can die (coral bleaching) or the growth can be greatly diminished.
- Coral ratios within the coral can also be used to estimate past climate because ocean temperatures affect a coral's chemistry.

(b) 'Economically more advanced countries have the global responsibility and monetary means to implement meaningful measures against global warming'.

To what extent do you agree with the above statement? Support your answers with relevant case studies. [16]

Suggested Answer:

Level 3 (13 – 16)	• Candidate gives good examples of 'meaningful' measures, exhibiting good understanding of what constitutes as meaningful measures against global warming. • Candidate gives a very nuanced and well-balanced argument to differentiate between the kinds of measure that DCs and LDCs could have done respectively within their monetary means, i.e., he/she acknowledges the role that LDCs, especially rapidly developing countries such as China and India need to play in order to contribute to mitigate against global warming. • Acknowleges, with good examples, the problems that DCs face if they were to implement certain global warming mitigation measures which might be extremely detrimental to the local economy, which in the US's case, might affect the global economy as well. • Good examples and case studies from both DCs and LDCs should be given.
Level 2 (8 – 12)	• Candidate acknowledges the nuances and problems involved in the DC's part in implementing the measures and the importance of getting the LDCs to acknowledge that they too, have a part to play in the mitigation against global warming. However, the candidate was not able to use good examples and case studies to illustrate or support this argument and therefore, renders it very weak. • Candidate has a reasonably good grasp of what constitutes as 'meaningful' measures against global warming,

Level 1 (0 – 7)	• Candidate simply described or explained the various measures that are being used to mitigate against the effects of global warming. • Candidate might try to differentiate between the measures that DCs and LDCs could do as mitigation but answer is superficial in simply saying that the DCs are economically more powerful and thus have the monetary means and power to implement measures. He/She might fail to acknowledge that the DCs sometimes have difficulty implementing measures as implementation might cause the country to incur huge economy losses. • Candidate might also present one side of the argument to say that DCs have ALL the means and responsibility to implement the measures, whilst LDCs should be given the right to develop at Earth's expenses. • No/little examples and case studies are given.

Introduction:

- **Outline the importance of implementation of measures against climate change and how these measures can be deemed as 'meaningful'. Candidates can also briefly outline some of the key effects of climate change, 'e.g.':** The bottom line is to reduce carbon dioxide, and in general, greenhouse gases emissions. Clearly, there will be a need for **international cooperation** to tackle such a measure to combat global warming.
- Candidate should also highlight the **importance of adopting an international approach to solve global climate problems as global warming and other climatic effects can have repercussions around the globe.** Candidates might also point out that as developed countries have more monetary means, they should take the lead in implementing or researching on such measures, whilst the developing countries should be kept in the loop.

Body:

- Example of how developed countries should take lead in implementing measures: The Montreal Protocol:
  - Global problems such as ozone depletion require international action. Legislation at the international level is difficult because of the lack of any single governing body that can impose standards and the inability to send in police to enforce regulations. Basically, nations have to agree to the legislation and that is why such laws often take years to negotiate and come into force.
  - **Developed nations need to** nations agreed to set aside money to help low income nations meet the conditions by buying substitutes for CFCs and halons. However, whilst the developed nations can do the above to help the low income nations buy substitutes, the low income nations MUST also see that the pollutant-inducing substance used for various productions is also eliminated properly and legally.
  - **Industry has many billions of dollars invested in equipment that is dependent on CFC-products and much of this equipment has a life-span of more than 20 years.** This equipment would have to be replaced prematurely. Studies have claimed that **outmoded and untested CFCs are being dumped on Third World counties because the Montreal Protocol allows these countries a longer period before CFCs have to be phased out.** Thus, it is the responsibility of both the developed and the developing countries to do their part in making sure that they follow the protocol strictly.

- **Candidate may also highlight the fact that because of the high cost of implementing or eradicating certain policies, some developed countries are not able to rectify certain climate change policies such as the Kyoto Protocol. Thus, whilst the developed countries might have the global responsibility to implement meaningful measures for climate change, they might actually not have the monetary means to do so as their local economy might then be adversely impacted, which could also affect other countries, especially in this globalised world.**
  - **Example:** In the long run, higher energy costs would reduce the use of energy by shifting production toward less energy-intensive sectors, by replacing energy with labour and capital in

specific production processes, and by encouraging energy conservation. Although reflecting a more efficient use of higher-cost energy, this gradual reduction in energy use would tend to lower the productivity of other factors in the production process.

- The emissions reductions called for in the Kyoto Protocol could have an adverse effect on Americans. The study finds, for example, that U.S. productivity following implementation of the Protocol would fall by $100 billion to over $400 billion in 2010.

- It is also predicted that increases in prices for gasoline would range from about 30% to over 50% and increases in prices for electricity from 50% to over 80%. Further, workers would suffer reductions in wage growth of 5% to 10% a year, while living standards would fall by 15%. Employment losses would be similarly significant. If all mandated carbon emissions targets are achieved domestically, every state in the United States will lose jobs. Total job losses are estimated at 2.4 million. Low- and moderate-income families would be hardest hit.

- U.S. competitiveness would be harmed as well. Developing countries would not need to raise their energy prices or product prices as the industrial countries would after implementing steps to meet their targets. U.S. output of energy-intensive products, such as automobiles, steel, paper, and chemicals, could decline by 15% by 2020. Rising energy costs would adversely affect U.S. agriculture as well, causing food exports to decline and food imports to increase.

- **Next, candidate should also point out the importance of the awareness of global responsibility from developing countries as well due to the fact that they are economies which are rapidly developing as thus will be heading towards high emission rates.** For example, As of August 27, 2008 China surpassed the United States as the world's biggest emitter of CO2 from power generation, according to new data from the Center for Global Development (CGD). China's GHG emissions have increased by 120% since the beginning of the decade, while U.S. emissions have barely changed over the same period.
  - In June 2007, China unveiled a 62-page climate change plan and promised to put climate change at the heart of its energy policies and insisted that developed countries had an "unshirkable responsibility" to take the lead on cutting greenhouse gas emission. This includes having a mandatory energy efficiency standard for buildings, which requires construction contractors to use energy systems in civil buildings, which aims for a 50% reduction in energy. In its 11th Five-Year Plan of 2005-2010, China also aims to fulfill its ambitious energy conservation target of a 20% reduction in energy per gross domestic product.

6 OR

(a) Discuss the formation and behaviour of the Inter-tropical Convergence Zone. [9]

Suggested Answer:

Inter-tropical Convergence Zone (ITCZ) is formed as a result of the convergence of **trade winds in the equatorial region**. It is the line that marks the meeting of the NE Trades and the SE Trades. Along the equator, strong solar heating causes air to **expand upward** and **diverge toward the poles.** This creates a zone of low pressure at the equator called the **equatorial low,** or the ITCZ.

The ITCZ is therefore a zone of convergence and weak horizontal airflow characterised by feeble and erratic winds. It is a globe-girdling zone of low-pressure associated with high rainfall, instability, and rising air in the Hadley cells.

It is not a region of continuously rising air, however. Almost all the rising air of the tropics ascends in the updrafts that occur in thunderstorms in the ITCZ, and these updrafts pump an enormous amount of sensible heat and latent heat of condensation into the upper troposphere, where much of it spread poleward. Due to this upward

motions that dominate the region, formation of heavy rain showers, particularly in the afternoon is very common in the ITCZ. The ITCZ is therefore the rainiest latitude zone in the entire world, with many location s accumulating more than 200 days of rain each year.

As the ITCZ is related to the intense heating at the equator, the changes in solar radiation received throughout the years at the equator thus affects the position of the ITCZ along the equator. Thus, the position of the ITCZ is not fixed and moves northwards and southwards with the overhead sun during the year.

During the June, the northern hemisphere experiences summer. The intense heating near the between the tropic of cancer and the equator will result in the ITCZ situated between 0-20ºN. The ITCZ is situated further up north when it is above land masses such as Asia as land heats up faster than the sea.

In January, the situation described above is reversed. Intense heating is prevalent between 0-20ºS.Hence, the ITCZ moves to the south hemisphere. The horizontal of intense low pressure is moved further southward at large land masses such as South America and Africa.

The position of the ITCZ for both January and July tend to be closer to the Equator over the ocean but migrates away form the Equator pole wards over the continents, particularly over the larger landmasses like Africa and Asia.

(b) Provide reasons to explain the presence of different climatic zones within Tropical Asia. [16]

Criteria	(tick)	Breakdown	Evidence
Introduction			
Relevance		The thesis statement answers the question.	Despite locating at lower latitude on Earth, there can still be varying climatic characteristics experienced by different locations within the Tropical Asia. This can be attributed to the differences in more localised climatic influences as discussed below.
Analysis		The question is broken down clearly.	
Body			
Paragraph 1: Assessing via a global scale			
Point		Clearly answers the question	Within Tropical Asia, many areas are generally experiencing similar climatic condition with generally high precipitation and high temperature.
		Reflects evaluation	
Explanation		Clear link made between point and question	Generally due to the relatively high angle of incidence, more intense heating will occur along the latitude where Tropical Asia falls under, thus explaining the high temperature. With the air rises, Tropical Asia will experience lower atmospheric pressure as compared to the areas along the Horse latitudes hence causing wind to blow from the Horse latitude to Tropical Asia. With greater wind moving towards Tropical Asia, more moistures will be gathered and thus explaining the presence of high rainfall.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	
Link Back		Consistent with argument presented	As such, due to the close latitudinal position, areas in Tropical Asia will experience similar climatic characteristics.
Paragraph 2: Regional differences cause some areas within Tropical Asia to experience different climatic conditions			
Point		Clearly answers the question	Yet, regional differences such as the position of overhead sun can result in regional climatic differences within Tropical Asia.
		Reflects evaluation	
Explanation		Clear link made between point and question	Taking Singapore and Thailand for instance, both countries falls within the region of Tropical Asia yet due to the difference in the overhead sun, both countries experience difference in their precipitation received throughout the year. Locating within the equatorial zone (0-5^0 N and S) its angle of incidence is constantly high throughout the year. As
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	

		Clear and concise	such, the rainfall received by Singapore remains high at around 200mm per month. Yet, locating further up North (5^0 to 30^0 N & S), Thailand will receive a lower amount of solar radiation during lower sun angle season (i.e.: winter solstice) when the sun is overhead the Tropic of Capricorn. This will result in Thailand experiencing seasonal variation in the amount of precipitation, which is also known as the Tropical Monsoon climate.
Link Back		Consistent with argument presented	As such, due to the difference in the position of the overhead sun, different types of climatic zone will be resulted.
Paragraph 3: Effects of sun angle is even more pronounced at higher latitude			
Point		Clearly answers the question	The effect of the overhead sun is even more pronounced at higher latitude.
		Reflects evaluation	
Explanation		Clear link made between point and question	Some parts of countries such as India do experience the Tropical Savannah climate. These areas are usually located higher up in terms of latitude and hence will experience a greater drop in temperature and precipitation during low sun angle period.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	Locating at higher latitude, the seasonal rainfall will drop even sharper as the position of the Inter-Tropical Convergence Zone shifts away from these areas rather than just moving slightly off the areas.
		Clear and concise	
Link Back		Consistent with argument presented	As such, although all these areas located within the Tropical Asia, the difference in latitude resulting in the difference in impact when the overhead sun changes, will cause the areas within Tropical Asia to experience slightly different climatic conditions.
Paragraph 4: Influence of sub-tropical highs			
Point		Clearly answers the question	Along the edge of Tropical Asia (15^0- 30^0 N & S), the presence of subtropical highs has resulted in a region of high temperature with extreme low precipitation
		Reflects evaluation	
Explanation		Clear link made between point and question	Taking the Gobi desert for instance, it is located within the Tropical Asia region but due to its higher latitudinal location, it is heavily influenced by the sub-tropical highs (Horse Latitude). With a higher atmospheric pressure, wind will be blown away from this area and hence resulting in low moisture content in the air and thus low amount of precipitation.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	

Link Back		Consistent with argument presented	As such, low-latitude desert will be formed in Tropical Asia.

Paragraph 5: Local influences

Point		Clearly answers the question	However, with the influence of even more localized climatic factors, different climate can still be formed even within the Tropical Rainforest, Tropical Monsoon, Tropical Savannah and low-latitude desert.
		Reflects evaluation	
Explanation		Clear link made between point and question	Local influences such as maritime and orographic influences can vary the local climate a little as they are also influenced by the sea temperatures or the presence of mountains to influence the location of the rainfall.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	
Link Back		Consistent with argument presented	Hence, there will still be variation in climate even within a climatic zone.

Paragraph 7: Conclusion to reiterate your stand

Point		Clearly answers the question	Upon assessing the above climatic influences, it is evident that the specific climatic condition an area will experience will have to depend on the combination effects of the climatic influences in the global, regional and local scale.
		Reflects evaluation	

7. EITHER

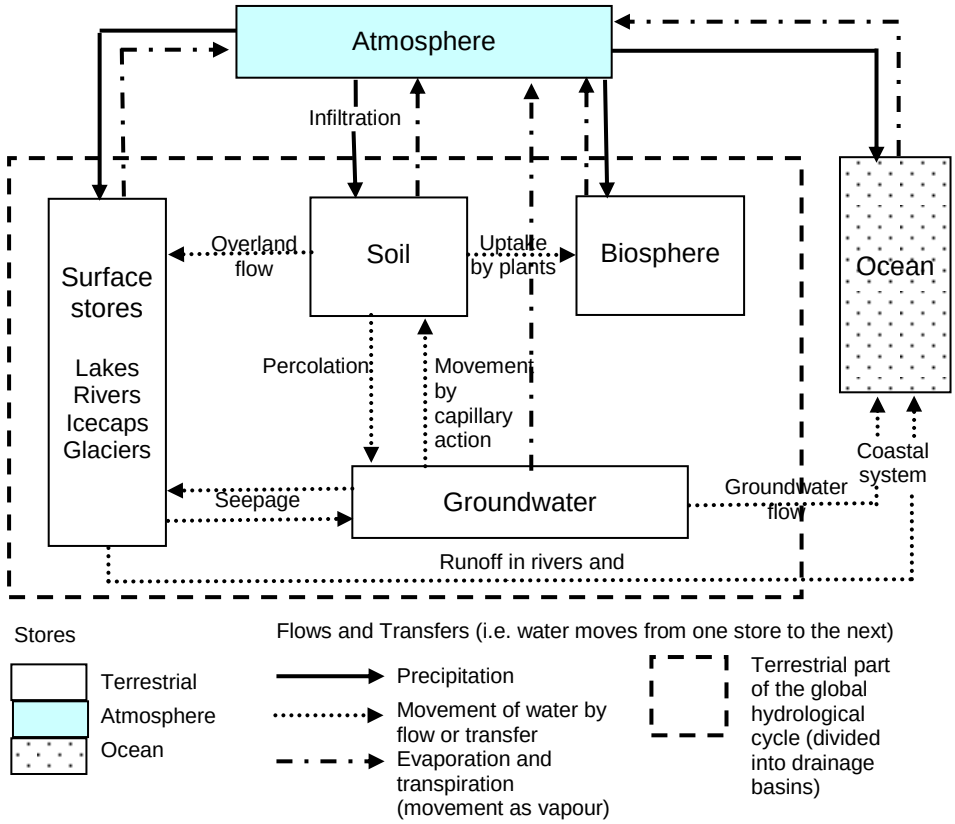
(a) Explain what is meant by the inputs, outputs, transfers and storages within a drainage basin system. [9]

Hydrologic Processes, Hazards and Management

7 EITHER

(a) With aid of well-annotated diagram(s), describe the differences between an open and a closed hydrological cycle system. [9]

Suggested Answers



Note: Whole diagram is an open hydrological cycle system. Terrestrial (dashed line box) is a closed hydrological cycle system.

A **hydrological cycle** is a process whereby water in the oceans, atmosphere and terrestrial lands move in a great series of continuous interchanges of both location and physical state. The hydrological cycle can be analysed as a system, so as to compare or contrast the processes acting at a variety of scales (i.e. global and local) and in various environments.

At the global scale, the hydrological cycle is a **closed system** as there is a fixed amount of water circulating within earth's atmosphere and on its terrestrial surfaces. There are no inputs or outputs of water, only energy (in the form of solar radiation). Also, on a global scale, water moves along pathways between these stores by processes, such as precipitation, evaporation and runoff.

On a local scale such as the earth's surface or even a single drainage basin, it will have inputs and outputs with two other parts of the global cycle – the atmosphere and the oceans. There are movements of both water and energy in and out of this localised system. In other words, there is no fixed amount of water circulating within the earth's surface or within a drainage basin as water can be

lost (as outputs) to the atmosphere and ocean. Similarly, water can enter (as inputs) into terrestrial surfaces and drainage basin. Hence, the terrestrial part of the global system (covering all the earth's surfaces) and specific drainage basins are therefore, an **open system**.

[Award max 3 marks for diagram, max 6 marks for describing differences between open and closed systems]

(b) Using specific examples, discuss how the physical and anthropogenic factors may influence a flood hydrograph. [16]

Criteria	(tick)	Breakdown	Evidence
Introduction			
Relevance		The thesis statement answers the question.	**A hydrograph** may be used to show how the water flow in a drainage basin (particularly river runoff) responds to a period of rain. The various elements of a hydrograph are influenced by both physical and anthropogenic factors as discussed below.
Analysis		The question is broken down clearly.	
Explanation		Rationale behind stand is clarified.	
Evaluation		A clear, balanced stand is presented in the thesis statement.	
		Various possible arguments have been presented.	
Body			
Paragraph 1: Physical factor – High rainfall			
Point		Clearly answers the question	The amount of rainfall received in an area can determine the amount for the peak discharge of a hydrograph.
		Reflects evaluation	
Explanation		Clear link made between point and question	With a higher rainfall received, the peak discharge will be higher. Taking for instance, it has been recorded for the Mississippi River, the peak discharge increased greatly for August 1993 when the rainfall received during a heavy rainfall season in August.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	
Link Back		Consistent with argument presented	Hence, it can be deduced that with a heavier rainfall, the peak discharge of a river will increase as well.
***Paragraph 2: Physical factor* – The relief of the slope and the rainfall intensity**			
Point		Clearly answers the question	The steepness of the rising limb of a hydrograph is affected by both the slope relief and rainfall intensity.
		Reflects evaluation	

Explanation		Clear link made between point and question	The shape of the **rising limb** depends on the intensity and duration of the rainstorm itself and the state of saturation of the regolith (antecedent soil moisture) at the start of the rainstorm. The prolonged light rain on an area will give a lower, flatter rising limb than a short, heavy shower on a saturated soil, even though both storms produce the same amount of rain The steeper the slopes of the drainage basins, the faster the flow of overland flows, resulting in steeper rising limbs
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	
Link Back		Consistent with argument presented	Hence, physical factors such as slope relief and rainfall intensity can affect the steepness of the rising limb.
Paragraph 3: **Physical factor – steepness of slope**			
Point		Clearly answers the question	Furthermore, the slope relief can also influence the lag time of a hydrograph.
		Reflects evaluation	
Explanation		Clear link made between point and question	Lag time is the time taken for water to flow from the point where it hits the ground to the gauging station, resulting in delay between the rainfall and peak discharge. There is a delay because of the numerous hydrological stores and flows that the water takes before entering the river channel. However, in a situation where the slope gradient is steep, discharge within the river is able to reach the gauging station faster and hence reducing the lag time. On the other hand, where slope gradient is low, lag time will be longer as the velocity discharge will not increase without the help of gravity.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	
Link Back		Consistent with argument presented	Hence, lag time can be affected by the slope gradient.
Paragraph 4: Anthropogenic factor - urbanisation			
Point		Clearly answers the question	Urbanisation near a river can result in that river having shorter lag time than before.
		Reflects evaluation	
Explanation		Clear link made between point and question	Man-made pipes can direct discharge to reach the gauging station faster. Furthermore, the increase of impermeable surfaces after urbanisation can cause peak discharge to increase as more runoff will be expected.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	It has been shown that between 1974 and 2000 there has been a considerably river peak discharge has increased and lag time shortened due to heavy urbanisation in the watershed of the Upper Thames River, of which the City of London is a part.
		Clear and concise	

Link Back		Consistent with argument presented	Hence, it is clear that with urbanisation, the elements of a hydrograph will be affected.
Paragraph 7: Conclusion to reiterate your stand			
Point		Clearly answers the question	Upon understanding the various elements of a hydrograph and their influencing factors, it is clear that both the physical and anthropogenic factors can determine the final outcome of a hydrograph.
		Reflects evaluation	

7 OR

(a) Suggest reasons why rivers meander. [9]

Suggested Answer:

A meander in general is a bend in a sinuous watercourse **[1m]**. A meander begins to form as a series of pools and riffles, which are alternating shallow and deep sections in a straight channel **[1m]**. Pools and riffles are both irregularities in the slope and depth of the river bed that develop in both natural and artificial channels, formed as a result of the combined effects of erosion and deposition **[1m]**.

The pool develops and become the concave side of the meander. The meander has one steep side (a river cliff) on the concave bend and a slip-off slope on the convex bend **[1m]**. The water is deep on the concave bend and shallow on the convex bend. This is due to the occurrence of erosion on the concave bend and deposition on the convex bend **[1m]**.

With the enlargement of pools (result of erosion) and riffles (result of deposition), the river becomes more sinuous **[1m]** and some of the deposited materials form point bars or shoals on the convex bend of the meander where velocity is low **[1m]**. The usual spacing between pools and riffles is usually very regular, being five to six times that of the width. This regular spacing is believed to be a result of a series of secondary flow within the main flow, known as helicoidal flow, where water flows around a meander in a corkscrew manner. The helicoidal motion tends to move material from the concave bend, and thus resulting in erosion on the concave bend and deposition on the convex bend **[1m]**.

As the river continues to erode on the outside of the bend and deposit on the inside, meanders continually change their position **[1m]**.

(b) Examine the main factors that determine a river's ability to erode its channel. [16]

Criteria	(tick)	Breakdown	Evidence
Introduction			
Relevance		The thesis statement answers the question.	The ability for a river to erode its channel can be categorised into two main groups – the natural factors and the anthropogenic factors.
Analysis		The question is broken down clearly.	
Explanation		Rationale behind stand is clarified.	
Evaluation		A clear, balanced stand is presented in the thesis statement.	
		Various possible arguments have been presented.	
Body			
Paragraph 1: **Natural factor - Velocity**			
Point		Clearly answers the question	The most obvious factor that can influence the erosive power of a river is the velocity of its discharge.
		Reflects evaluation	
Explanation		Clear link made between point and question	Generally, the higher velocity enables the river to carry larger particles. The competence of a river is measured by the largest transported particle. The greater the volume of water flowing down a channel enables a greater load to be carried, so the capacity of the river is increased, thus increasing the river's velocity.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	
Link Back		Consistent with argument presented	As such, with a higher discharge, velocity will be higher and in turn increasing the river's ability to erode.
Paragraph 3: **Natural factor - The geology of the channel**			
Point		Clearly answers the question	Physical **characteristics of soil** that made up the channel also have a bearing on erodibility of a river.
		Reflects evaluation	
Explanation		Clear link made between point and question	Soil properties influencing erodibility include texture, structure and cohesion. Soil having a large amount of silt-sized particles is most susceptible to erosion from water. Soil with clay or sand-sized particles is less prone to erosion.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	Structure influences both the ability of the soil to

		Clear and concise	absorb water and its physical resistance to river erosion. The last property to consider is cohesion. When moist, the individual soil particles in a cohesive soil cling together to form a doughy consistency. Clay soils are very cohesive, while sand soils are not.
Link Back		Consistent with argument presented	As such, soil with a smoother texture, weaker structure and cohesiveness will allow the river to erode its channel more easily.
Paragraph 4: Natural factor – Presence of vegetation			
Point		Clearly answers the question	**Vegetation** is probably the most important physical factor influencing river channel erosion.
		Reflects evaluation	
Explanation		Clear link made between point and question	A good cover of vegetation shields the river bank from the impact of running water. It also binds the soil together, making it more resistant to runoff. A vegetative cover provides organic matter, slows runoff, and filters sediment.
		Clear link made between point and evidence (Pointed out significance of facts)	
Evidence		Relevant and accurate facts provided	
		Clear and concise	
Link Back		Consistent with argument presented	Thus, presence of vegetation and how dense it is can determine a river's ability to erode.
Paragraph 5: Anthropogenic factor - Channelisation			
Point		Clearly answers the question	Channelization can stabilize a river's banks hence greatly reducing the river's ability to erode.
		Reflects evaluation	
Explanation		Clear link made between point and question	When a river is channelized, its banks will be covered with concrete. The hardness of concrete will make river channel erosion extremely difficult.
		Clear link made between point and evidence (Pointed out significance of facts)	
Link Back		Consistent with argument presented	As such, human activities such as changing the characteristics of the river bank through channelization can influence the river's ability to erode its channel.
Paragraph 6: Anthropogenic factor - Urbansation			
Point		Clearly answers the question	Urbanisation near a river can result in that river having greater discharge than before.
		Reflects evaluation	
Explanation		Clear link made between point and question	Man-made surfaces such as concrete result in greater run-off. Rain water reaches rivers faster

		Clear link made between point and evidence (Pointed out significance of facts)	and can cause flooding and thus moving water washes away fertile soil.
Evidence		Relevant and accurate facts provided	It has been shown that between 1974 and 2000 there has been a considerably river bank erosion due to heavy urbanisation in the watershed of the Upper Thames River, of which the City of London is a part.
		Clear and concise	
Link Back		Consistent with argument presented	Hence, it is clear that with urbanisation, river discharge will increase, leading to greater river channel erosion.
Paragraph 7: Conclusion to reiterate your stand			
Point		Clearly answers the question	Upon adopting holistic point of view, one needs to examine to both the physical and anthropogenic factors in order to better predict a river's ability to erode its channel.
		Reflects evaluation	

~ End of Paper ~

Copyright Acknowledgements:

Question 1	Photograph A	http://www.ccma.vic.gov.au/soilhealth/photos.htm Last accessed on: 12th August 2015
Question 2	Fig. 1	http://idaholyoaks3.blogspot.sg/2012/11/understanding-climate-change-part-3.html Last accessed on: 12th August 2015
	Fig. 2	Adapted from http://www.science-story.com/images/countries.jpg Last accessed on: 10th August 2015
Question 3	Fig. 3	http://www.physicalgeography.net/fundamentals/8b.html.Last accessed on: 12th August 2015
Question 4	Figs. 4A & 4B	www.seafriends.org.nz/enviro/Soil/geosoil.htm Last accessed on: 11th August 2015