# Energy transfers -- Earth [29 IB marks—15 class marks possible]

No resubmissions after graded allowed. If this is submitted after the answer key is posted (or more than 1 full week late), you will be deducted 10% (1.5 pts)

**Part 1: Multiple choice –** circle or highlight your answer choice (If I can’t find it in a quick glance, I won’t grade it). 0.5 pts per question for an attempt; 0.5 pts per question for correctness. No resubmissions after being graded allowed.

**1.** *[1 mark]*

The average temperature of the surface of a planet is five times greater than the average temperature of the surface of its moon. The emissivities of the planet and the moon are the same. The average intensity radiated by the planet is . What is the average intensity radiated by its moon?

A.

B.

C.

D.

**2.** *[1 mark]*

What is meant by the statement that the average albedo of the Moon is 0.1?

A. 10% of the radiation incident on the Moon is absorbed by its surface

B. 10% of the radiation emitted by the Moon is absorbed by its atmosphere

C. 10% of the radiation incident on the Moon is reflected by its surface

D. 10% of the radiation emitted by the Moon is at infrared wavelengths

**3.** *[1 mark]*

The orbital radius of the Earth around the Sun is 1.5 times that of Venus. What is the intensity of solar radiation at the orbital radius of Venus?

A. 0.6 kW m-2

B. 0.9 kW m-2

C. 2 kW m-2

D. 3 kW m-2

**4.** *[1 mark]*

Light of intensity *I*0 is incident on a snow-covered area of Earth. In a model of this situation, the albedo of the cloud is 0.30 and the albedo for the snow surface is 0.80. What is the intensity of the light at P due to the incident ray *I*0?

![](data:image/png;base64;base64,)

 A.   0.14 *I*0

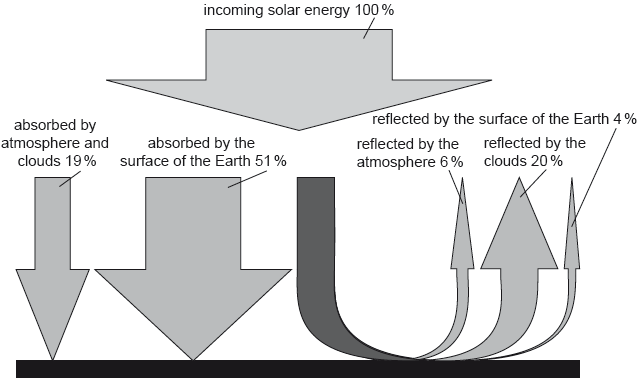
B.   0.24 *I*0

C.   0.50 *I*0

D.   0.55 *I*0

**5.** *[1 mark]*

The diagram shows a simple climate model for the Earth.



What does this model predict for the average albedo of the Earth?

A.     0.30

B.     0.51

C.     0.70

D.     0.81

**6.** *[1 mark]*

Three gases in the atmosphere are

          I.     carbon dioxide (CO2)

          II.     dinitrogen monoxide (N2O)

          III.     oxygen (O2).

Which of these are considered to be greenhouse gases?

A.     I and II only

B.     I and III only

C.     II and III only

D.     I, II and III

**7.** *[1 mark]*

A black body emits radiation with its greatest intensity at a wavelength of Imax. The surface temperature of the black body doubles without any other change occurring. What is the wavelength at which the greatest intensity of radiation is emitted?

A. Imax

B.

C.

D.

**8.** *[1 mark]*

The average albedo of glacier ice is 0.25.

What is ?

A.  0.25

B.  0.33

C.  2.5

D.  3.0

**9.** *[1 mark]*

The solar constant is the intensity of the Sun’s radiation at

A. the surface of the Earth.   
B. the mean distance from the Sun of the Earth’s orbit around the Sun.  
C. the surface of the Sun.   
D. 10km above the surface of the Earth.

**10.** *[1 mark]*

A black body of surface 1.0m2 emits electromagnetic radiation of peak wavelength 2.90×10–6m. Which of the following statements about the body are correct?

I.    The temperature of the body is 1000 K.  
II.   The energy radiated by the body in one second is 5.7×104 J.  
III.  The body is a perfect absorber of electromagnetic radiation.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**Part 2: short answer—**Use information from your notes and from your textbook and data booklet to help you answer these. You will be graded for giving an honest attempt, whether or not your answer is completely correct. Just try, then compare your answers to the answer key after that is posted later in the week.

🡪 10 question parts, up to 0.5 pts each = 5 pts total for this section.

**11a.** *[1 mark]*

The average temperature of ocean surface water is 289 K. Oceans behave as black bodies.

Show that the intensity radiated by the oceans is about 400 W m-2.

P = e \* σ A T4

P/A = e \* σ \* T4

P/A = 1 \* 5.67 \* 10-8 Wm-2K-4 \* (289 K)4

P/A = 395.53 W m-2 ≈ 400 W m-2

**11b.** *[3 marks]*

Explain why some of this radiation is returned to the oceans from the atmosphere.

Some of this radiation is returned to the oceans from the atmosphere because the radiation is absorbed by the greenhouse gases in the atmosphere. This is because the majority of wavelengths radiated from the Earth are infra-red and the gases in the atmosphere tend to absorb infrared and ultraviolet radiation. From here, the greenhouse gases re-emit this radiation in all directions, and part of this radiation ends up on the oceans again, which absorbs part of.

**11c.** *[2 marks]*

The intensity in (b) returned to the oceans is 330 W m-2. The intensity of the solar radiation incident on the oceans is 170 W m-2.

Calculate the additional intensity that must be lost by the oceans so that the water temperature remains constant.

P = e \* σ A T4

P/(A\*e\*σ) = T4

(330 + 170 W m-2)/( 1\*5.67 \* 10-8 Wm-2K-4) = T4

(500 W m-2)/( 1\*5.67 \* 10-8 Wm-2K-4) = T4

8,818,342,151.675 = T4

T = 306.44 K

Current Temperature of the Ocean: 289 K

Change: 17.44 K

P = e \* σ A T4

P/A = e \* σ \* T4

P/A = 1 \* 5.67 \* 10-8 Wm-2K-4 \* (17.44 K)4

P/A = 0.00525 W m-2

**11d.** *[1 mark]*

Suggest a mechanism by which the additional intensity can be lost.

The additional intensity can be lost through evaporation as the sun warms the ocean for as particles leave the ocean as vaporized liquid, energy will be lost from the ocean, therefore keeping the temperature constant and losing this additional intensity.

**12a.** *[2 marks]*

The ratio  = 1.5.

Show that the intensity of solar radiation at the orbit of Mars is about 600 W m–2.

**12b.** *[2 marks]*

Determine, in K, the mean surface temperature of Mars. Assume that Mars acts as a black body.

Mean Intensity = I = S / 4

I = 600 / 4 W = 150 W

P/A = e \* σ \* T4

T = 226.79 230 K

**12c.** *[2 marks]*

The atmosphere of Mars is composed mainly of carbon dioxide and has a pressure less than 1 % of that on the Earth. Outline why the greenhouse effect is not significant on Mars.

The greenhouse effect is not as significant on Mars because lower atmospheric pressure means that there are not as many gas molecules in the atmosphere. This means there are very few molecules that capture and then re-radiate radiation back to Mars, therefore lessening any processes of the greenhouse effect.

**13a.** *[2 marks]*

The Sun has a radius of 7.0×108m and is a distance 1.5×1011 m from Earth. The surface temperature of the Sun is 5800 K.

Show that the intensity of the solar radiation incident on the upper atmosphere of the Earth is approximately 1400Wm−2.

P = e \* σ A T4

*I* = 1397. 36 W m−2 1400W m−2

**13b.** *[2 marks]*

The albedo of the atmosphere is 0.30. Deduce that the average intensity over the entire surface of the Earth is 245Wm−2.

1400 \* 0.30 = 420 W m−2

1400 – 420 = 980 W m−2

I = S / 4 = 980 W m−2 / 4 = 245 W m−2

**13c.** *[2 marks]*

Estimate the average surface temperature of the Earth.

I = e \* σ T4

245 W m−2 =

T = 256 K

Printed for SKYLINE HIGH SCH

© International Baccalaureate Organization 2021

International Baccalaureate® - Baccalauréat International® - Bachillerato Internacional®