Complete the assignments below.

Physical Science

Week 1:
☐ Chemical Reactions Part 1 (SC.912.P.8.7) ☐ Content Area Reading: Life's Little Essential

Week 2:
☐ Chemical Reactions Part 2 (SC.912.P.8.8) ☐ Content Area Reading: Gravitational Waves

Week 3:

Week 4:

Chemical Reactions Word/Equation Sort Name:______________________________

Part 1 (With Group) Directions:

Stamp: ______

Please label each of the columns for one of the five reaction types.

1. Sort all of the provided cards into the five categories.
2. Show the teacher your work so far to get it checked.
3. Record your information in the table.
4. Once you have received a stamp for Part 1, you may proceed to Part 2.

Synthesis	Decomposition	Single Replacement	Double replacement	Combustion
•				
•				•
•				•
•				•
•				
•				

Part 2 (Individual) Directions:

1. List the five types of reactions.
2. In your own words/visual representation, describe/define/explain each of the reactions using the above sort as a guide.

Type of Reaction	Description of reaction in your own words and drawings
•	•
•	•
•	•
•	•
•	•

Cooking or digesting proteins break the peptide bonds and fragment the proteins.	**Cakes rise (get fluffy) because the baking soda in the mix breaks down and produces carbon dioxide bubbles.**
Propane gas in a grill burns in oxygen to produce heat, carbon dioxide and water.	**Cellular respiration is a controlled reaction between glucose and oxygen that produces energy, water and carbon dioxide.**
Rockets are fueled by a mixture of hydrogen gas and oxygen gas that combine to release energy and form only water as a product.	**Hydrogen peroxide breaks down to form water and oxygen gas.**

An iron fence rusts in air, becoming iron oxide.	**Sulfur gas in onions is released when they are cut and combines with the moisture in your eyes to form stinging sulfuric acid.**
Caramelization occurs when heat drives hydrogen and oxygen (as water) from sugar.	**In a battery zinc metal replaces the copper in copper nitrate.**
Kidney stones are formed when the calcium in compounds in our bodies switches place with the hydrogen in oxalic acid to make two new compounds. One of them is calcium oxalate (kidney stones) So don’t eat a lot of peanuts, chocolate, or sweet potatoes if you have kidney stones because they are high in oxalic acid.	**The final step in extracting pure lead from lead ore is to mix lead oxide with carbon. The carbon replaces the lead in the compound and pure lead is left.**

In the last step of the gold refining process, zinc replaces gold in the gold cyanide compound producing pure gold.	**Milk of magnesia is actually the compound magnesium hydroxide. The magnesium switches places with the hydrogen in excess hydrochloric acid in your stomach, forming water and magnesium chloride, two neutral compounds.**
$Na + H_2O \rightarrow NaOH + H_2$	$Li + N_2 \rightarrow Li_3N$
$Al_2SO_3 \rightarrow O_2 + Al$	$C_4H_{10}O + O_2 \rightarrow CO_2 + H_2O$

Combustion	Single Replacement
Synthesis	Decomposition
There is only 1 reactant	There is only 1 product

Double Replacement	2 ionic compounds
1 reactant is O_2 The products are water and carbon dioxide	$AB \rightarrow A + B$
Element and compound	$NaOH + KNO_3 \rightarrow NaNO_3 + KOH$

$C_xH_y + O_2 \rightarrow H_2O + CO_2$	$A + B \rightarrow AB$
$A + BC \rightarrow AC + B$	$AB + CD \rightarrow AD + CB$
$C_5H_{12} + O_2 \rightarrow CO_2 + H_2O$	

$Pb(NO_3)_2 + KI \rightarrow PbI_2 + KNO_3$	$Mg + O_2 \rightarrow MgO_2$
$H_{2(g)} + O_{2(g)} \rightarrow H_2O_{(g)}$	$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$
$C_{12}H_{22}O_{11(s)} \rightarrow C_{(s)} + H_2O_{(g)}$	$NaOH \rightarrow NaO + H_2O$

$Na_2CO_3 \rightarrow Na_2O + CO_2$	$Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$
$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)}$	$AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$
$Ag_2O \rightarrow Ag + O_2$	$CH_{4(g)} + O_{2(g)} \rightarrow H_2O_{(g)} + CO_{2(g)}$

$Al_{(s)} + CuCl_{2(aq)} \rightarrow AlCl_3(aq) + Cu_{(s)}$	$Cl_{2(g)} + KBr(aq) \rightarrow KCl_{(aq)} + Br_{2(l)}$
$NaBr_{(aq)} + AgNO_{3(aq)} \rightarrow Na(NO_3)_{2(aq)} + AgBr_{(s)}$	$H_2SO_{4(aq)} + NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + H_2O_{(l)}$
$C_2H_{6(g)} + O_{2(g)} \rightarrow H_2O_{(g)} + CO_{2(g)}$	$C_3H_{8(g)} + O_{2(g)} \rightarrow H_2O_{(g)} + CO_{2(g)}$

Gravitational waves detected 100 years after Einstein's prediction

LIGO opens new window on the universe with observation of gravitational waves from colliding black holes

Aerial view of the LIGO laboratory in Louisiana.

February 11, 2016

For the first time, scientists have observed ripples in the fabric of spacetime called gravitational waves, arriving at Earth from a cataclysmic event in the distant universe. This confirms a major prediction of Albert Einstein's 1915 general theory of relativity and opens an unprecedented new window to the cosmos.

Gravitational waves carry information about their dramatic origins and about the nature of gravity that cannot be obtained from elsewhere. Physicists have concluded that the detected gravitational waves were produced during the final fraction of a second of the merger of two black holes to produce a single, more massive spinning black hole. This collision of two black holes had been predicted but never observed.

The gravitational waves were detected on Sept. 14, 2015 at 5:51 a.m. EDT (09:51 UTC) by both of the twin Laser Interferometer Gravitational-wave Observatory (LIGO) detectors, located in Livingston, Louisiana, and Hanford, Washington. The LIGO observatories are funded by the National Science Foundation (NSF), and were conceived, built and are operated by the California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT). The discovery, accepted for publication in the journal *Physical Review Letters*, was made by the LIGO Scientific Collaboration (which includes the GEO Collaboration and the Australian Consortium for Interferometric Gravitational Astronomy) and the Virgo Collaboration using data from the two LIGO detectors.

Based on the observed signals, LIGO scientists estimate that the black holes for this event were about 29 and 36 times the mass of the sun, and the event took place 1.3 billion years ago. About three times the mass of the sun was converted into gravitational waves in a fraction of a second -- with a peak power output about 50 times that of the whole visible universe. By looking at the time of arrival of the signals -- the detector in Livingston recorded the event 7 milliseconds before the detector in Hanford -- scientists can say that the source was located in the Southern Hemisphere.

According to general relativity, a pair of black holes orbiting around each other lose energy through the emission of gravitational waves, causing them to gradually approach each other over billions of years, and then much more quickly in the final minutes. During the final fraction of a second, the two black holes collide at nearly half the speed of light and form a single more massive black hole, converting a portion of the combined black holes' mass to energy, according to Einstein's formula $E=mc^2$. This energy is emitted as a final strong burst of gravitational waves. These are the gravitational waves that LIGO observed.

The existence of gravitational waves was first demonstrated in the 1970s and 1980s by Joseph Taylor, Jr., and colleagues. In 1974, Taylor and Russell Hulse discovered a binary system composed of a pulsar in orbit around a neutron star. Taylor and Joel M. Weisberg in 1982 found that the orbit of the pulsar was slowly shrinking over time because of the release of energy in the form of gravitational waves. For discovering the pulsar and showing that it would make possible this particular gravitational wave measurement, Hulse and Taylor were awarded the 1993 Nobel Prize in Physics.

The new LIGO discovery is the first observation of gravitational waves themselves, made by measuring the tiny disturbances the waves make to space and time as they pass through the earth.

"Our observation of gravitational waves accomplishes an ambitious goal set out over five decades ago to directly detect this elusive phenomenon and better understand the universe, and, fittingly, fulfills Einstein's legacy on the 100th anniversary of his general theory of relativity," says Caltech's David H. Reitze, executive director of the LIGO Laboratory.

The discovery was made possible by the enhanced capabilities of Advanced LIGO, a major upgrade that increases the sensitivity of the instruments compared to the first generation LIGO detectors, enabling a large increase in the volume of the universe probed -- and the discovery of gravitational waves during its first observation run.

"In 1992, when LIGO's initial funding was approved, it represented the biggest investment NSF had ever made," says France Córdova, NSF director. "It was a big risk. But NSF is the agency that takes these kinds of risks. We support fundamental science and engineering at a point in the road to discovery where that path is anything but clear. We fund trailblazers. It's why the U.S. continues to be a global leader in advancing knowledge."

"This detection is the beginning of a new era: The field of gravitational wave astronomy is now a reality," says Gabriela González, LSC spokesperson and professor of physics and astronomy at Louisiana State University.

"The description of this observation is beautifully described in the Einstein theory of general relativity formulated 100 years ago and comprises the first test of the theory in strong gravitation. It would have been wonderful to watch Einstein's face had we been able to tell him," says Weiss.

"With this discovery, we humans are embarking on a marvelous new quest: the quest to explore the warped side of the universe -- objects and phenomena that are made from warped spacetime. Colliding black holes and gravitational waves are our first beautiful examples," says Thorne.

Fulvio Ricci, Virgo spokesperson, notes that: "This is a significant milestone for physics, but more importantly merely the start of many new and exciting astrophysical discoveries to come with LIGO and Virgo."

Bruce Allen, managing director of the Max Planck Institute for Gravitational Physics adds: "Einstein thought gravitational waves were too weak to detect, and didn't believe in black holes. But I don't think he'd have minded being wrong!"

"The Advanced LIGO detectors are a tour de force of science and technology, made possible by a truly exceptional international team of technicians, engineers, and scientists," says David Shoemaker of MIT, the project leader for Advanced LIGO. "We are very proud that we finished this NSF-funded project on time and on budget."

At each observatory, the 2 1/2-mile (4-km) long, L-shaped LIGO interferometer uses laser light split into two beams that travel back and forth down the arms (four-foot diameter tubes kept under a near-perfect vacuum). The beams are used to monitor the distance between mirrors precisely positioned at the ends of the arms. According to Einstein's theory, the distance between the mirrors will change by an infinitesimal amount when a gravitational wave passes by the detector. A change in the lengths of the arms smaller than one-ten-thousandth the diameter of a proton (10^{-19} meter) can be detected.

"To make this fantastic milestone possible took a global collaboration of scientists -- laser and suspension technology developed for our GEO600 detector was used to help make Advanced LIGO the most sophisticated gravitational wave detector ever created," says Sheila Rowan, professor of physics and astronomy at the University of Glasgow.

Independent and widely separated observatories are necessary to determine the direction of the event causing the gravitational waves, and also to verify that the signals come from space and are not from some other local phenomenon.

Toward this end, the LIGO Laboratory is working closely with scientists in India at the Inter-University Centre for Astronomy and Astrophysics, the Raja Ramanna Centre for Advanced Technology, and the Institute for Plasma to establish a third Advanced LIGO detector on the Indian subcontinent. Awaiting approval by the government of India, it could be operational early in the next decade. The additional detector will greatly improve the ability of the global detector network to localize gravitational-wave sources.

"Hopefully this first observation will accelerate the construction of a global network of detectors to enable accurate source location in the era of multi-messenger astronomy," says David McClelland, professor of physics and director of the Centre for Gravitational Physics at the Australian National University.

This is an adapted version of an article in the public domain by the National Science Foundation. The complete version of the article can be retrieved at the following link:
http://www.nsf.gov/news/news_summ.jsp?cntn_id=137628&org=NSF&from=news

Text-Dependent Questions and Writing Prompt for Complex Text

Article Title: Gravitational Waves Detected 100 Years After Einstein's Prediction

Vocabulary Questions:

1. "It was a big risk. But NSF is the agency that takes these kinds of risks. We support fundamental science and engineering at a point in the road to discovery where that path is anything but clear. We fund **trailblazers**." Using context clues, describe what the NSF director, France Córdova, means when he says that they fund **"trailblazers."**

2. Using evidence from the text to inform your response, describe what Dr. David Reitze means by the term **"elusive phenomenon,"** as used in his quote in paragraph 8.

Text Evidence/Content Questions:

1. What are gravitational waves and how are they formed? Be sure to use evidence from the text to support your response.

2. Using the text to inform your response, describe how scientists detected gravitational waves using Advanced LIGO detectors.

3. Inferring from the information presented in the article, describe two reasons why collaboration is extremely important in gravitational wave detection research.

Writing Prompt:

A scientific theory is explanation of natural phenomena that has been repeatedly confirmed through experimentation and observation. Using evidence from the text, explain how Einstein's theory of general relativity is a culmination of many scientific investigations, including the recent detection of gravitational waves.